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INTERNATIONAL ASSOCIATION FOR LANDSCAPE ECOLOGY

IALE 2023 World Congress

BOOK OF ABSTRACTS

& Programme

Transboundary Resource Management, Climate Change and Environmental Resilience
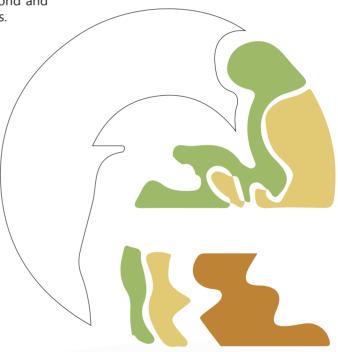
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http://iale2023.org

The International Association for Landscape Ecology (IALE) is the world wide organization for landscape ecologists. Our primary mission is to promote global collaborations, among our various chapters and with international policymakers. We also serve as a platform for discussion and interactions across the disciplines. We achieve our mission through working groups, frequent communications to members, and a World Congress (held every 4 years) and regional conferences. We also support our many active chapters around the world and members via travel grants and capacity building grants.
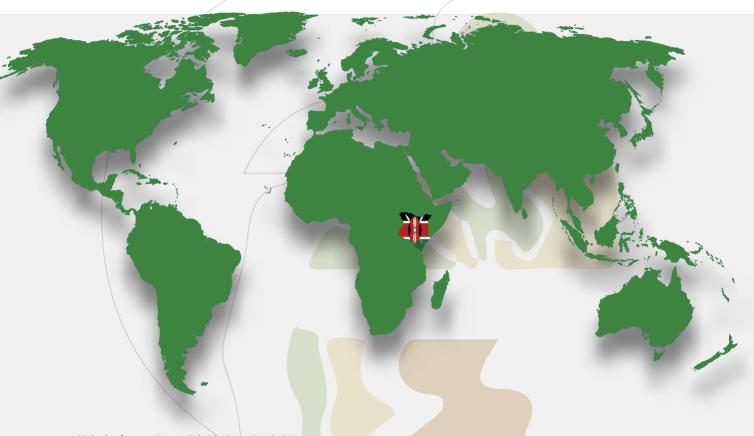
CONTENT

WORLD MAP

iale2023

- **Main Conference Venue:** Safari Park Hotel, Nairobi Kenya
- **Satellite Venues:**
- Kenyatta University Nairobi Kenya
- The Regional Center for Mapping of Resources for Development (RCMRD), Nairobi Kenya

CONFERENCE OVERVIEW

The International Association for Landscape Ecology (IALE)
The International Association for Landscape Ecology (IALE) is the worldwide organization for landscape ecologists. Our primary mission is to promote global collaborations, among our various chapters and with international policymakers. We also serve as a platform for discussion and interactions across the disciplines. We achieve our mission through working groups, frequent communications to members, and a World Congress (held every 4 years) and regional conferences. We also support our many active chapters around the world and members via travel grants and capacity building grants.

The AFRICA-IALE (Africa Chapter)
Africa IALE is a chapter of the International Association of Landscape Ecology (IALE). Landscape ecology draws together expertise from both biophysical and socioeconomic sciences to explore basic and applied research questions concerning the ecology, conservation, management, design/planning, and sustainability of landscapes as coupled human-environment systems. The concept is increasingly being used to study complex landscape patterns and ecological functions emerging from the impacts of human activities on natural resources.

The 2023 IALE World Congress
The IALE World Congress occurs every four years and is the premier event for landscape ecologists worldwide to address topics in landscape ecology that range from local to global in scale. During the World Congress, landscape ecologists from public, private, and non-profit sectors will address a broad spectrum of environmental challenges and their potential solutions. The 2023 World Congress will be a hybrid (online/in person) event and it is for the first time being hosted in the Global South. The World Congress theme is 'Transboundary Resource Management, Climate Change and Environmental Resilience'. The World Congress will include plenaries, symposium, oral sessions, posters sessions, a social dinner, and field trips. It is jointly hosted by Kenyatta University (KU), Regional Center for Mapping of Resources for Development (RCMRD), National Museum of Kenya (NMK), Institute of Climate Change and Adaptation Institute, University of Nairobi (UON), the United Nations Environment Programme (UNEP) and in collaboration with the African-Chapter of IALE (Africa-IALE).

Theme: 'Transboundary Resource Management, Climate Change and Environmental Resilience'

Conference Sub-Themes
- Transboundary ecosystems in the Anthropocene:
- The shared ecosystems and natural resources across country boundaries and the anthropogenic effects.
- How human activities are altering these transboundary ecosystems
- Managing climate risk in transboundary ecosystems: Climate change and global warming   in the transboundary ecosystems; mitigation, adaptation, geoengineering,
  Borderlands, cross-border resources, and environmental resilience: Strengthening
  resilience in borderlands ecosystems, disturbance of ecosystems
- Building resilience and security: Food security, water security, and livelihoods
- Climate resilient livelihoods: Climate resilient agricultural practices, adaptive agriculture, agroecology,
- Data science and geospatial technology for sustainable landscape management:
- Drivers of landscape change and sustainability at multiple scales
- Ecological sustainability in urban landscapes and smart cities
- Water-Energy-Food nexus

iale2023 World Congress Session Program

Days/Dates	Morning			Afternoon			Evening
Sunday **July 09, 2023**	**Pre-Conference Workshops**						
	8:30 – 10:00 AM	**10:20 – 11:50 AM**	**1:00 – 2:30 PM**	**2:50 – 4:20 PM**	**4:40 – 6:00 PM**	**6:30 – 9:00 PM**	
Monday **July 10, 2023**	**Welcome to Magical Nairobi** *(IALE 2023 Prelude)*	**Opening ceremony** (10:00AM) *(Jambo Hall)*	**Parallel Technical & Panel Sessions**	**Parallel Technical Sessions**	*Poster Session* **(Jambo Foyer)**	**IALE EC Meeting** **Welcome Cocktail Reception**	
Tuesday **July 11, 2023**	**Parallel Technical Sessions**	**Keynote Plenary 1** *(Jambo Hall)*	**Parallel Technical & Panel sessions**	**Parallel Technical Sessions**	*Poster session* **(Jambo Foyer)**	**IALE Chapter Meetings**	
Wednesday **July 12, 2023**	**Parallel Technical Sessions**	**Keynote Plenary 2** *(Jambo Hall)*	**Parallel Technical & Panel sessions** **Landscape Ecology Editorial Board Meeting**	**Parallel Technical Sessions**	*Poster session* **(Jambo Foyer)**	**IALE General Assembly** (7:00 – 9:30PM)	
Thursday **July 13, 2023**	**Parallel Technical Sessions**	**Keynote Plenary 3** *(Jambo Hall)*	**In-congress Excursions (local)** *- Conference attendees are responsible for Excursions cost** **Workshop #6:** Developing a Strategy for Writing Papers & Research Outputs *(Safari Park Hotel)* **Workshop #7:** Skills, infrastructure, and equitability issues for landscape-scale ecological research in developing countries *(Kenyatta University)*			**Open Topic meetings** - IALE Working Groups,	
Friday **July 14, 2023**	**Parallel Technical Sessions**	**Keynote Plenary 4** **(Jambo Hall)**	**Parallel Technical Sessions**	**Closing Ceremony** **(Jambo Hall)**		**Social Dinner & Show** (Famous Safari Cats Dancers Acrobats)	
Saturday **July 15, 2023**	**Post-conference Excursions & Tours** - Conference attendees are responsible for Excursions & Tours						

SPECIAL GUEST OF HONOR

HONORABLE SOIPAN TUYA
CABINET SECRETARY
MINISTRY OF ENVIRONMENT - CLIMATE CHANGE AND FORESTRY
KENYA

Honorable Soipan Tuya is the Cabinet Secretary, Ministry of Environment, Climate Change and Forestry – Kenya. She has served as a two term member of parliament for Narok County (ten years). While in the National Assembly, she served as 1st Chairperson of Speaker's Panel (alternate Speaker) and has also served as a specially elected senator in the 4th Senate of Kenya. Hon. Soipan is an exceptionally motivated legal professional and an Advocate of the High Court of Kenya of 18 years standing.

Kenyatta University Vice Chancellor's Welcome Message for IALE2023 World Congress

PROF. PAUL K. WAINAINA, Ph.D.
VICE CHANCELLOR,
KENYATTA UNIVERSITY

On behalf of Kenyatta University, it is my pleasure and honor to welcome you all to Nairobi, Kenya, to attend and participate in the 11th World Congress of the International Association for Landscape Ecology (IALE) from 10th to 15th, July 2023. The conference theme is "Transboundary Resource Management, Climate Change and Environmental Resilience"; and will include pre-conference workshops and post-conference excursions. I welcome you to join us and to be part of our knowledge sharing in respect to the conference theme. Kenyatta University is honored to be the primary co-host of this high level global event which is happening for the very first time in the Global South. I urge you all to take this once in a lifetime opportunity to share your experiences and learn from one another about developments in scientific frameworks, technological and modelling tools for resource assessment, and environmental management.

I also welcome you to visit Kenyatta University during your stay and to also sample the great tourism attractions in our country.

I look forward to meeting you at the Congress!

Karibuni sana

Joy Obando
Host of Local Organizing
Committee (Prof. Joy Obando)

Prof. Moses Azong Cho

Robert Scheller,
IALE President 2021-2023

Welcome Messages 2023 IALE World Conference

On behalf of the Local Organizing Committee I am pleased to welcome you to Nairobi City, Kenya to the IALE World Congress which will take place from 10th -15th July 2023. The theme of the conference: 'Transboundary Resource Management, Climate Change and Environmental Resilience'. We are happy to host you and wish to assure you that Nairobi is exceptionally beautiful, accessible and safe. July is an excellent time to visit Kenya, because the cool dry weather reduces the malaria incidence. It will also be a good time to visit the game parks and reserves to see wildlife and enjoy the post conference excursions. We look forward to welcoming you to Nairobi.

The first ever IALE World congress to be hosted by IALE Africa couldn't have come at a more opportune time. At a time when our continent is at the crossroads of opportunities and challenges for sustainable development and when Africa IALE seeks to broaden its global footprint. We are buoyed by this opportunity and will not miss the chance to showcase Africa and the opportunities for sustainable landscape development on the continent to the global landscape ecology community. The conference theme "Transboundary Resource Management, Climate Change and Environmental Resilience" couldn't be more fitting. It is well aligned with The African Union Agenda 2063, Africa's development blueprint to achieve inclusive and sustainable socio-economic development. We therefore welcome all and sundry to the beautify city of Nairobi in 2023. Karibuni!

To the Landscape Ecologists of the World:
We are incredibly excited to welcome everyone to Nairobi for our 2023 World Congress! Whether you are a long-time member of the International Association for Landscape Ecology (IALE) or you were invited to give a talk or you are simply passionate about landscapes and landscape change, all are welcome to learn and to connect and to share with us. As the pace and scale of global change continues to accelerate, the world needs landscape ecology more than ever.

We are proud of our history bridging disciplines, seeking applied solutions, and connecting scientists and practitioners from across the globe. Our host committee and host city epitomize this commitment. Africa generally, and Kenya specifically, contain some of the most diverse landscapes in the world and truly represent our shared future with global changes expressed as local management challenges. No longer can we consider our landscapes - and their management needs, including for food security, biodiversity, and climate mitigation - as independent or isolated problems. All are connected by our global culture, economy,

Conference Organization
- Kenyatta University
- Local Organizing Committee
- Africa-IALE
- IALE International
- International Scientific Advisory Committee

Local Conference "Hosting" Collaborators:
- Kenyatta University (KU)
- Regional Center for Mapping of Resources for Development (RCMRD)
- The International Centre of Insect Physiology and Ecology (icipe)
- Local Organizing Committee (LOC)
- Prof. Joy Obando (Chair), Department of Geography, Kenyatta University, Nairobi, Kenya
- Prof. Simon Onywere (Co-Chair), Department of Spatial and Environmental Planning, Kenyatta University
- Prof. Richard Oduor, Ag. Registrar, Division of Research, Innovation and Outreach (RIO), Kenyatta
- University, Nairobi, Kenya
- Julius Gichohi, Ag. Director Capacity Building and Training (RCMRD), Nairobi, Kenya
- Paul Idude, Director Corporate Services (RCMRD), Nairobi, Kenya
- Prof. Chris Shisanya, Agro-Climatology Professor of Geography, Kenyatta University, Nairobi, Kenya
- Dr. Anthony Macharia, Biogeography and Ecosystems, Department of Geography, Kenyatta University, Nairobi, Kenya
- Dr. Esther Munyiri, Director, Global Tourism Resilience & Crisis Management Centre
- (GTRCMC) Eastern Africa
- Dr. Peter Wangai, Department of Environmental Studies and Community Development, Kenyatta University, Nairobi, Kenya
- Dr. Jane Wangu Njuguna, Senior Deputy Director, Research and Development, Kenya Forestry Research Institute
- Dr Elfatih M. Abdel-Rahman, Research Scientist, Data Management, Modelling and
- Geo-Information Unit, icipe
- Margaret Nthuli, Industry Leads, Non-Profits, ESRI Eastern Africa

International Scientific Advisory Committee
- Prof Moses Azong Cho - University of Pretoria, South Africa (Chair)
- Dr. Henry N. N. Bulley - BMCC, City University of New York, USA
- Prof. Dr. Christine Fürst - Martin Luther University Halle-Wittenberg, Germany
- Prof. Cristian Echeverria, University of Concepción, Chile
- Prof. Niina Käyhkö - University of Turku, Finland
- Prof. Dolors Armenteras - National University of Colombia, Columbia
- Prof. Erica A. H. Smithwick, The Pennsylvania State University, USA
- Prof. Bryan C. Pijanowski, Purdue University, USA
- Prof. Sima Fakheran Esfahani, Isfahan University of Technology, Iran
- Prof. Irene Petrosillo, University of Salento, Italy
- Dr. Bernadette Arakwiye, World Resources Institute- Africa, Rwanda
- Dr. Aniko Polo-Akpisso, Université de Lomé, Togo
- Prof. Carlos Morera Beita, National University of Costa Rica
- Prof. Jan Bogaert, Université de Liège (Gembloux Agro-Bio Tech), Belgium
- Dr. Ramesh Krishnamurthy, Wildlife Institute of India, India

IALE 2023 KEYNOTE SPEAKERS

Prof. Dolors Armenteras
Landscape Ecology and Ecosystem Modelling Lab-ECOLMOD, Universidad Nacional de Colombia

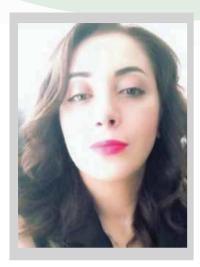Dolors Armenteras is a biologist from the University of Barcelona and holds an MSc in Environmental Forestry from the University of Wales, as well as a PhD in Geography from King's College London, UK, where she also served as a Visiting Research Fellow (2004-2007). She is a member of the UK Research and Innovation (UKRI) Development Peer Review College. Since 1998, she has been based in Colombia, where she currently holds the position of Full Professor of Landscape Ecology at the Universidad Nacional de Colombia in Bogotá. She is also a member of the Colombian Academy of Sciences. Her research focuses on landscape ecology, including the dynamics, causes, and consequences of deforestation, spatial ecology, and the impacts of global change on biodiversity conservation. She also investigates the responses of forests and biodiversity to human-induced disturbances and specializes in fire ecology, risk reduction, and adaptation to climate change. Dr. Armenteras is the author or co-author of over 200 publications and serves on several editorial boards. With over two decades of experience, she has actively contributed to the science policy interface by proposing and demonstrating solutions, pathways, and policy-relevant options. She was honored as a Fulbright Regional Network for Applied Research (NEXUS) Climate Change and Biodiversity Scholar. She has participated in various UNEP GEOs (Global Environmental Outlook), contributed to the Millennium Ecosystem Assessment, and served as an expert in the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). Currently, she holds the position of Vice-President of the International Association of Landscape Ecology (IALE) and is a Member of the Scientific Panel for the Amazon. Dr. Armenteras is also a co-author of the UNEP Rapid Assessment Report titled "Spreading like Wildfire: The Rising Threat of Extraordinary Landscape Fires." Furthermore, she actively contributes as a Member of the UN Convention to Combat Desertification (UNCCD) Science-Policy Interface (SPI).

Prof. Dr. Christine Fürst
Vice President for Research, Internationalisation and Transfer Halle (Saale), Germany

Martin-Luther-Universität Halle-Wittenberg Prorektorin für Forschung, Internationalisierung und Transfer (Vice President for Research, Internationalization and Transfer) Halle (Saale), Germany

Dr. Parisa Pakzad
Strategic Land Use Planning/Green Infrastructure Sustainability NSW Department of Planning and Environment Sydney, Australia

Dr. Emmanuel Nkurunziza
Director General RCMRD, Kenya

Dr Parisa Pakzad is a distinguished professional with a strong background in the field of green infrastructure and spatial analysis. Holding a PhD from the University of New South Wales, Parisa has dedicated her research and expertise to developing innovative GIS models for measuring and evaluating green infrastructure performance. Currently serving as a Senior Planning Officer in the Department of Planning and Environmental, Parisa plays a pivotal role in strategic planning and design initiatives. Her expertise and insights contribute to the development and implementation of sustainable urban planning practices that seamlessly integrate green infrastructure and enhance the overall livability of cities. Throughout her career, Parisa has successfully bridged the gap between the private and public sectors, leveraging her knowledge and experience to bring about positive change. Her collaboration with various stakeholders has resulted in the implementation of innovative strategies that prioritize sustainability, resilience, and community well-being.
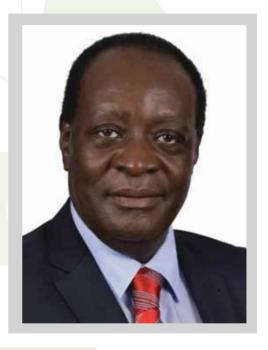
Emmanuel Nkurunziza is currently Director General of the Regional Centre for Mapping of Resources for Development (RCMRD). RCMRD is an intergovernmental organisation with 20 Member States in Eastern & Southern Africa. He has also served as the Director General of Rwanda Natural Resources Authority and Chief Registrar of Land Titles in Rwanda. He joined the Rwanda Natural Resources Authority in 2011 and before this Mr. Nkurunziza was the Director General of the National Land Centre and Registrar of Land Titles where he initiated and facilitated roll out of a nationwide land registration programme.

Humbulani Mudau
*CEO at South African National Space Agency
(SANSA) City of Johannesburg, Gauteng,
South Africa*

Humbulani Mudau has over 20 years of technical and management experience in Space Science and Technology, particularly in Earth Observation systems, space technology development, as well as remote sensing, and geospatial applications. Mr Mudau has vast experience in inter-governmental, interagency, regional, global and international space diplomacy while lobbying on policy issues and resource mobilisation for national and international projects. Over the years, he has led at executive level, showcasing his robust and concrete capabilities in project designing, implementing and evaluating international projects with diverse stakeholders. In his capacity as the senior scientific representative at GEO Secretariat in Geneva, Switzerland, he conceptualised the African Group on Earth Observations (AfriGEO) initiative. Later on, as the Chief Director of Space Science and Technology in the South African government, he was responsible for the implementation of the Department of Science and Technology's 10-year Innovation Plan – that included the National Space Strategy and South African Earth Observation Strategy (SAEOS) – as well as the

establishment of the of the South African National Space Agency (SANSA) and the National Earth Observation and Space Secretariat, among many other initiatives. Academically he holds a Masters in Satellite Remote Sensing from the University of Paris VI; a B.Sc. Honours in Environmental Management and Geospatial Sciences from University of Johannesburg; a Certificate in Remote Sensing from University of Johannesburg; and a B.Sc. Biological Sciences from University of Venda

Hon. Dr. Wilber Ottichilo
Vihiga County Governor, Kenya

Prof. Jianguo (Jingle) Wu
*Dean's Distinguished Professor of
Landscape Ecology & Sustainability,
Arizona State University Science*

Dr. Henri Tonnang
Head a Principal Scientist and Head of Data
Management, Modelling and Geo-information
(DMMG) Unit of the International Centre of Insect
Physiology and Ecology (ICIPE).

Dr Tonnang conducts outstanding work in Africa and
beyond, undertaking cutting-edge research for
world-class research organizations, developing and
applying mathematical methods to shape
decision-making, address societal issues, create wealth,
and contribute to the development of the continent
and beyond focusing on food security, resource
management, health, climate change and
environmental resilience. Dr Tonnang has worked for
the International Institute of Tropical Agriculture (IITA),
the International Maize and Wheat Improvement
Center (CIMMYT), and the International Potato Centre
(CIP), and in partnership with national research and
educational institutions in Benin, Cameroon, Ethiopia,
Nigeria, Kenya, Tanzania, Uganda, Zimbabwe, Malawi
and South Africa, just to mention a few African
countries

Eng. Sylvester Matemu
*Executive director Nile Basin
Initiative Secretariat Entebbe,
Uganda*

Organizer: Dr. Luis Inostroza[1*]

Editor's Guide to Successful Publishing

[1]*Associate Editor - Ecosystem Services*

Primary Contact: *luis.inostroza@mendelu.cz*

How can you increase your chances to get your manuscript published? Writing a scientific article is is to discuss with young scholars about key publishing aspects from the editorial point of view, to help a successful publication process. The workshop will be interactive. Using Mentimeter (www.mentimeter.com), we will induce a structured discussion along the reviewer's and the editor's points of view. These two different angles may help to better understand and manage a manuscript to pass the screening of experts. The workshop is designed to be practical, providing guidelines for good practices and effective recommendations, as well as highlighting common errors and misunderstandings in the publishing process to be avoided.

Mentoring and Networking: Building Your Support Network for a Successful Career in Landscape Ecology

Organizers: Amy Frazier[11*], Jennifer Costanza[2]; Dolors Armenteras[3]; Monika Egerer[4]; Sima Fakheran[5]; Sarah Gergel[6]; Somayeh Mohammadi Hamidi[7]; Anita Morzillo[1]; Joy Obando[8]; Marketa Santruckova[9]; Robert Scheller[10]

complex and demanding. It can be also frustrating. Many times is difficult to find a successful path toward publication. Indeed, the scientific publishing ecosystem is complex and can be overwhelming when you are starting your academic career. The aim of this workshop

The IALE Diversity and Inclusion Committee: [1]*USA,* [2]*Committee Chair,* [3]*Colombia,* [4]*Germany,* [5]*Iran,* [6]*Canada,* [7]*Germany,* [8]*Kenya,* [9]*Czechia,* [10]*IALE President* *and* [11]*Arizona State University*

Primary Contact: *Amy.Frazier@asu.edu*

Finding a mentor can be intimidating, especially when you are early in your career. Research has shown that people who are in successful mentoring relationships often experience higher rates of career satisfaction, increased chances for promotion, and even high monetary compensation. People who are involved in mentoring relationships feel more personal connection to the mission, values, and culture of their workplace and often report more certainty and positivity about their future within an organization. Similarly, networking is among the most important skills that is almost never taught in school and is also an important aspect for successful science diplomacy. A strong network can help you succeed across the many different facets of your professional life. This workshop will explore why mentoring and networking matter, how to find and connect with a mentor, and what the roles,

responsibilities, and expectations are for both the mentor and mentee. Participants will engage in hands-on activities to begin building their own mentoring networks, and small group discussions about the challenges of finding and connecting with mentors. At the end of the workshop, participants will be able to: implement strategies to find and connect with a mentor, understand core mentoring skills for mentors and mentees, and recognize and emulate effective allies who are championing a more equal workplace.

Spatial Scaling of Categorical Data

Organizers: Daniel Gann[1*]

[1]*Florida International University, USA*

*Primary Contact: gannd@fiu.edu

Land-cover class definitions are scale dependent. Up-scaling of categorical data must account for that scale dependence but applying most scaling algorithms for categorical data (e.g., majority rule, nearest neighbour) assumes the validity of the classification system at the lower resolution regardless of the scale factor and leads to high and uncontrolled loss of information in the scaled dataset. This workshop will demonstrate why it is important to consider information loss and how to quantify it. Participants will then be introduced to multi-dimensional grid-point (MDGP) scaling (Gann 2019, https://doi.org/10.1111/2041-210X.13301), a new scaling algorithm that accounts for the scale dependence of classification systems as data are spatially aggregated. This algorithm aggregates categorical data while simultaneously controlling for information loss and generating a non-hierarchical, representative, classification system for the aggregated scale. The hands-on component of this course introduces a new R package for landscape scaling of categorical data. The algorithm evaluates information retention and class representativeness of scaled classification systems while aggregating spatial data. Applications of the scaling algorithm will be presented with examples in vegetation and ecosystems ecology.

Hierarchical Models of Species Distribution

Organizers: Tammy L. Wilson[1*] and Alexej Sirén[2]

[1]*U.S. Geological Survey, Massachusetts Cooperative Fish and wildlife Research Unit, University of Massachusetts and* [2]*University of Vermont*

*Primary Contact: tammywilson@umass.edu

Hierarchical models flexible tools that are extremely useful for species distribution modelling given presence-absence and count data. The framework we present is an accessible overview of hierarchical modelling types useful for evaluating single-species distribution, multi-species distribution, and models of species abundance. We use simulation to help students fully grasp model structure and fit models with base R and the R package Unmarked. We will first give an overview of monitoring data types and how these data types can be leveraged in the hierarchical framework. We then discuss imperfect detection and explore how and why it might be important to model it explicitly. We

then introduce a single species occupancy model and use data simulation to understand how inference could be impacted if imperfect detection were ignored. We extend this basic model to multiple species, and models of abundance using simple count data. This course is aimed at students, practitioners, and early career professionals. Basic working knowledge of R, and familiarity with generalised linear models is assumed, but knowledge of advanced statistics or Bayesian inference is not necessary.

Capacity Building in Emerging Geospatial Technologies for Earth Observation Data Analyses for Climate Change and Ecosystem Resilience in Africa

Organizers: Jane Bemigisha[1*], Henry Bulley[2], Julius Gichohi[3], Elfatih Abdel-Rahman[4], Simon Onywere[5] and Meshack Kinyua Ndiritu[6]

[1]ESIPPS International Ltd/Gender, Climate Change and Agriculture in Africa Research Institute, Uganda, [2]BMCC, City University of New York, USA [3]Regional Centre for Mapping of Resources for Development, [4]International Centre of Insect Physiology and Ecology (ICIPE), [5]Dept. of Spatial & Environmental Planning, Kenyatta University and [6]GMES & Africa Support Program, & Space, African Union Commission

*__Primary Contact:__ bemigisha@yahoo.co.uk

The last decade has seen increased focus on integrating Landscape Ecology principles and Geospatial Science techniques to assess landscape change dynamics and resilience of ecosystem services in African Countries. Landscape ecology principles such as scale and heterogeneity are vital for effective analyses and modelling of land use dynamics, and how these affect the provisioning of ecosystem services. Current developments in Earth Observation systems have also resulted in rapid increase in the volume of available geospatial data that are often dissimilar, dynamic, and dispersed. This is underscored by the Africa Union's Agenda 2063 Flagship African Outer Space Programme. The quest to effectively utilize these disparate multisensor and multiscale data have also led to an increase in synergies between Geospatial computing and Big Data analytics. In particular, Geospatial Artificial Intelligence (GeoAI) and Machine Learning (ML) have become vital tools for geospatial data management, processing via multi-sensor and multiscale data fusion, analyses, modelling, and visualization to improve environmental planning and decision making. This workshop is aimed at developing the capacity of scientists from African countries to take advantage of improvements in (GeoAI) and Machine Learning (ML) in their work. That said, we intend to reserve about 60 percent of participation to African women scientists.

Developing a Strategy for Writing Papers & Research Outputs

Organizers: Merham Keleg[1,2*], Maggie Roe[3], Tim Waterman[4], Emma Waterton[5], and Vanesa Castan Broto[6]

[1]*Ain Shams University, Egypt,* [2]*Landscape Research Group, United Kingdom,* [3]*Newcastle University - Landscape Research Group, United Kingdom,* [4]*University College London - Landscape Research Group, United Kingdom,* [5]*University of York - Landscape Research Group, United Kingdom, and* [6]*University of Sheffield – Landscape Research Group, United Kingdom*

*Primary Contact: *merhamkeleg@eng.asu.edu.eg*

A hands-on capacity building workshop for graduate students and early career researchers for 'writing and submitting articles to scientific journals- Landscape Research Journal as a case study. The workshop session is based around sharing knowledge and understandings of written outputs from research. The session will examine key issues to overcome and provide opportunities to discuss the development of skills and strategies for improving your writing skills and output strategy.

Skills, Infrastructure and Equitability Issues for Landscape-Scale Ecological Research in Developing Countries

Organizers: Martin Wilkes[1*], James Jumbe[2], Joy Obando[2], Mary Makokha[2], Francis Kariuki[2], Anthony Macharia[2], Anthony Kebira[2], Fredrick Maloba[2], Jacinter Amadi[2], Rebecca Karanja[2], Thomas Kibutu[2], and Raphael Kweyu[2]
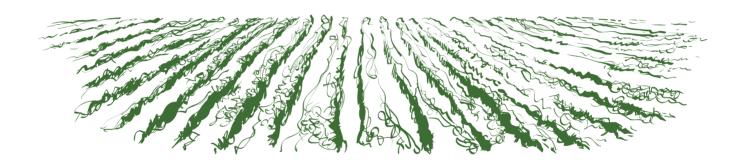
[1]University of Essex, UK, [2]Kenyatta University, Kenya.

*Primary Contact: m.wilkes@essex.ac.uk

This workshop will focus on identifying strategies for building capacity in landscape-scale ecological research in developing countries. Participants will assess existing research infrastructure and the research skill base, identify areas that require investment in equipment and training, and discuss the equitability of access to career development opportunities regardless of gender, socioeconomic background, and career stage. The workshop aims to help participants understand how to build capacity for landscape-scale ecological research by addressing skills, infrastructure, and equitability issues. Through the sharing of knowledge and experiences, participants will enhance their awareness of these issues, enabling them to support sustainable development, social welfare, and the resolution of complex social-ecological challenges.

IALC 2023

SYMPOSIUM PAPER SESSIONS

Agricultural Landscapes in
Europe and Africa for
Sustainable Intensification

Scale and Patchiness Affect Species Distribution of Plants and Animals along Productivity and Fragmentation Gradients at a Semi-Arid Agroecological Landscape

Yaron Ziv[1]

[1]*Ben-Gurion University of the Negev, Israel*

Southern Judea Lowlands, Israel, is a patchy agro-landscape, located along a North-South productivity gradient and an East-West fragmentation gradient, serving as a model system for studying landscape ecology's questions. For various studies we defined three landunits along the productivity gradient (3X4 km each), within each 10-20 isolated natural habitat patches of different size and isolation have been identified. We used remote sensing and GIS, as well as field-oriented data collections of spatial (e.g., connectivity), physical (e.g., stoniness) and biotic (e.g., annuals) factors, at different scales (plot, patch, cluster of patches, landunit, landscape). Focusing on arthropods, we used network analysis that represents metacommunity structures of different groups of species, to explore the local and landscape determinants of common and rare species diversities and whether the relative importance of patches is similar for common and rare species of different taxa. While *Coleoptera* and *Hemiptera* showed a strong association between patch connectivity and rare species, but low association for common species, *Araneae* showed high association between patch connectivity and both common and rare species. This is mediated by the species relation with the landscape matrix. We found that common and rare species of each taxon are affected by different spatial scales and the variation between groups are larger than the inter-taxa variation. Calculating the patches' relative importance for different groups allowed to identify several important patches for the entire metacommunity for future conservation. Using one species (*Zophosis punctata*) to explore the mechanisms affecting species distribution, we showed that the landscape's fragmentation may lead to changes in the thermal conditions of patches. Such increases in patch temperature explained well the variation in locomotion across each landunit. Beetles from highly fragmented landunits, which included warmer patches, showed high locomotor intermittence-frequent pausing events during locomotion, which may reflect their ability to move between patches to survive.

Landscape Structure and Flowering Plant Species Richness affect Bumblebees' Movement and Navigation Capacity

Riho Marja[1*], Edina Török[1], Gyula Pinke[2], Gábor Koltai[2], Thomas Frank[3], Péter Batáry[1]

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Pollinator movements to surrounding and foraging areas and their spillover in agricultural landscapes have gained only limited attention. However, this is one of the key aspects related to different species' dispersal, reproduction, as well as their ecosystem service provisioning. We combined the marking of individual commercial bumblebees (*Bombus terrestris*) with RFID tags with a homing experiment as a promising novel method to increase the understanding of pollinator movements. We carried out the experiment in two countries: Hungary and Austria. Both countries were almost five decades divided by the Iron Curtain, which resulted in a stark contrast in landscape structure, especially in field sizes. Large-scale agricultural systems with large arable fields are common in Hungary. In contrast, agricultural landscapes in Austria are characterized by small and very narrow fields. Additionally, we also studied the effects of proximity to semi-natural habitats (close vs. far), crop type (oilseed rape or cereal) and landscape-level flowering plant species richness for bumblebees' behaviour (average time reach to the home colony). Our results showed that bumblebees returned faster to the home colony if it was placed close to semi-natural habitats and if the flowering plant species richness was high. However, bumblebees also returned faster to the colony, if semi-natural habitats were far and flowering plant species richness was low. Furthermore, we found that in the case of the large fields (in Hungary), bumblebees returned faster to the colony if the flowering plant richness was high and also in the cases of small fields (in Austria) if flowering plant species richness was low. With crop type, we did not find significant interaction. Thus, landscape variables (proximity of semi-natural habitats and field sizes) have an effect on bumblebees' behavior and navigation capacity, but this can be modulated by the landscape level richness of flowering plants.

Nature Based Solutions to Promote Pest Regulation, Pollination and Related Species Diversity at Landscape Scale, in a Long-Term Socio-Ecological Research Site in South Western France

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Societal demand for multifunctional agricultural landscapes keeps increasing. Nature based solutions (NBS) consider the benefits of biodiversity and green infrastructures to support multiple ecosystem services but also their positive impact on the associated biodiversity, not directly involved in the ES provision. Ecosystem services based on mobile organisms such as pest regulation and pollination should be considered at landscape scale. In this study we examined how landscape heterogeneity could promote pest regulation and pollination and related species diversity in 36

landscapes of the ZA PYGAR, a Long-Term Socio-Ecological Research site in South Western France. Pest regulation was evaluated by predation cards (dead aphids, seeds, lepidopteran eggs) and potential of pollination was based on strawberry phytometers. We show how the different components of landscape heterogeneity (composition, configuration) and practices at local scale influence the predation rate on cards, strawberry weight, as well as carabid, spider and wild bee diversities. Wild bees seemed to be more affected by landscape heterogeneity than local practices with no effect on pollination. The production mode and local farming practices had more effects on predators like carabids and spiders. The first results showed than Nature Based Solutions such as grasslands or hedgerows planting would rather support wild bees' diversity with no effect on pollination service while extensification of local practices and greening of the landscapes would favour predators' diversity and pest regulation.

Quantification, Mapping and Assessment Approaches for Agroecosystem Services

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Agroecosystems have been modified by people over long time periods to produce food, fibre, fuel and other goods and services for human consumption and processing. The major agroecosystem types are cropland and grassland, which can be both intensively and less intensively managed ecosystems. In order to safeguard the long-term supply of desired ecosystem services, agroecosystems are heavily dependent on the constant flow of other – mainly regulating – ecosystem services that together with often significant human inputs (e.g., fertilisers, herbicides, pesticides, energy, water, labour) enable coproduction of - mainly provisioning - goods and services. Most quantifications of – mainly provisioning - agroecosystem services such as the UN System of Environmental Economic Accounting (SEEA EEA) rely on output/supply and use indicators such as yields in tons per hectare or animal numbers. In this presentation, alternative approaches to quantify, map and assess the co-production and use of different agroecosystem services using case studies on different scales in Germany will be presented. For instance, an alternative indicator system for provisioning agroecosystem services, model-, GIS- and UAV-based as well as conceptual considerations will be shown. These methods can be used to deliver spatially explicit information that is needed for sustainable agriculture, including precision and low input farming.

Why has European Agriculture Changed Over the Last 50 Years? A Farm-Level Perspective

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Looking at European agriculture over the last 50 years, there have been many changes, often linked to technological advances, which have changed the intensity of land use and increased agricultural yields while reducing manual labour. These developments have also led to dramatic changes in agricultural

landscapes, affecting not only biodiversity, soil and water quality, but also the economic and social sustainability of farmers and rural communities. While there is a wealth of historical research on agricultural change in general, there is still little insight into the reasons for developments at the farm level. Given that farmers are key actors in both agriculture and landscape development, we focus in this research on actor rationales for on-farm change. To follow up this aim, we conducted 123 oral history interviews (OHI) with elderly and experienced farmers in 13 study sites across Europe. Using the driving forces framework, we then analysed the OHIs inductively for a range of technological, natural, institutional, economic and cultural/personal factors that influenced farmers' decisions. Overall, economic and institutional drivers were found to play a central role, closely followed by technological and cultural driving forces. Whereas some driving forces have been mentioned by the farmers in all study sites, others seem to have a similarly high, but site-specific relevance. In the presentation we will reflect on the methodology and the identified driving forces of farm change that ultimately affect sustainability outcomes and the structure and composition of agricultural landscapes.

Have European Agricultural Landscapes and Farms become more Sustainable over the last 20 Years?

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Agricultural landscape development is the consequence of multiple decisions by individual farmers. There has been broad agreement for decades now, that European farms and agricultural landscapes should become more sustainable. But how have they actually evolved over the

past 20 years and how can the degree of sustainability be evaluated? We mapped landscape changes in 17 study sites across Europe between 2000 and 2020 and interviewed 274 farmers in total, across the study sites that cover a geographical gradient and various levels of farming intensity. We derived indicators for landscape and farm development and for the farmers' perception about how their situation evolved. We interpreted the indicator changes according to their alignment with different value systems, ranging from productivism (production is the top priority) to post-productivism (economic, environmental and societal outcomes are rated in a more equilibrated manner). We found that, while many study sites show indicators of post-productivism at landscape scale, farm scale indicators mostly indicate a continued productivist paradigm. Only in the sites with the most intensive farming practices, and in mountainous sites, there was a trend towards post-productivism also at farm level. Yet, those farmers' livelihood indicator outcomes were lower than for productivist farmers, indicating that they changed their farming practices out of necessity but not out of conviction. In three sites, both landscape and farm scale indicators aligned towards productivist pathways. There farmers tended to have a higher job satisfaction and a better perceived economic situation. Three sites are on a marginalisation pathway, and this is perceived by farmers as worsening their livelihoods. Interestingly, the majority of farmers, whatever study site or development pathway they are on, claim that societal valuation of the agricultural sector has decreased over the last 20 years. Successful agricultural transformation will require an enabling environment that provides social and economic incentives, increased training and education and a supportive civil society.

Agricultural Technology as the Pathway Towards Sustainable Intensification of European Farming Landscapes

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The challenges of increasing food demand, managing limited resources, and adapting to climate change lead to the necessity of developing sustainably intensified agricultural systems. Agricultural technology relates to the development of machines, devices, and sensors to support productive, efficient and environmentally friendly farming, which will in turn affect agricultural landscapes and ecosystem services. Patenting plays a key role in technology diffusion, but the actual technology uptake in specific regions varies by, among others, structural composition of the farming sector, farm size, and farmer incomes. We combined a systematic patent review with site-based surveys to investigate to what extent the development and diffusion of agricultural technology matches with actual technology adoption in 7 European arable farming sites, and to what extent future technologies will support sustainable intensification. We classified 600,000 patents at global scale over the last 50 years and linked them to the different targets of sustainable intensification. The site-based survey explored experts'

predictions on technology adoption, challenges and solutions of water management, fertilization, and weed/pest control. By comparing the results from patent review and site-survey, we speculate on the actual contribution of future agricultural technologies to support sustainable intensification.

Evaluating Degradation in Land Cover for The Reference and Monitoring Periods of the UN Land Degradation Neutrality in Switzerland

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Land degradation impacts most terrestrial biomes across all world regions. To address global change challenges emanating from degrading natural resources, many countries voluntarily set themselves the goal of achieving Land Degradation Neutrality (LDN). Baseline conditions are to be established over a reference period (2000 – 2015). With seven more years to monitor the SDG 15.3.1 until the year 2030, the scientific basis for operationalizing LDN is still evolving. The non-availability of annual land use-land cover maps of sufficient resolution in various countries, among them, Switzerland is a major factor hampering the assessment at national and local levels. To fill this gap, we assess land cover change for seven land categories (that is, Tree-covered area, Grassland, Cropland, Wetland, Artificial Surfaces, Otherland, and Waterbody). Land cover change is a major LDN sub-indicator required to assess the proportion of degraded land to total land area (Sustainable Development Goal 15 indicator — SDG15.3.1). Annual land cover datasets from 2015 to 2020 were produced at 10m from Sentinel-1 and Sentinel-2 images using a Google Earth Engine and GIS-based workflow. An evaluation of degradation in land cover is presented in support of the operationalization of LDN in Switzerland. Drawing upon the understanding that changes made to land use-land cover may act as precursors to land degradation processes, transitions relating to the loss of natural cover were identified during the reference and the monitored periods. Such transitions were grasslands to tree-covered areas and croplands to artificial surfaces due to settlement development. For example, the amount of cropland converted to artificial surface areas was greater in absolute terms during the monitored period than during the reference period. Also, the regeneration of natural cover involving transitions from otherland to grassland and from grasslands to tree-covered areas was found. Overall trends between 2000 and 2020 in Switzerland are the increasing settlement areas in the Central Plateau, the Alpine valleys of Valais and Ticino largely at the expense of croplands and the bush encroachment of pastures such as in

the Jura. This study's contributions include an enhanced workflow for annual land cover mapping and the development of annual land cover maps for the entire Switzerland. It also provides a potential source to fill the gap between the production cycles of the Swiss Corine and *Arealstatistik* land use data.

Integrating Modelling and Earth Observation to Assess the Impact of Climate Shocks on Cropping Systems in Kenya

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Sustainable cropping systems are essential for meeting the growing demand for food while minimizing the negative environmental impacts of agriculture. However, climate extremes such as droughts and heat stress can significantly impact crop production. This research presents two novel approaches aimed at improving the understanding of impacts of climate shocks on agriculture in Kenya. The first approach proposes a unique integration of data on cropping systems, drought information, and climate forecasting to generate essential agro climatic indicators for decision-making. The method leverages existing crop type information and optical and radar time series to create early-season crop maps that can facilitate the implementation of new adaptation technologies and increase agricultural productivity. The second approach utilizes Earth Observation (EO) technology to monitor crop condition and cropping systems with higher spatial and temporal resolution. Here it is tested to use high- resolution crop management information based on multisource remote sensing data, such as irrigation and contextual information on cropping practices to assess the drought impact. These approaches are scalable to other regions and aim to produce crop condition information, which will enable farmers and policy makers to take timely and informed decisions on crop management, irrigation, and harvesting. These innovative solutions aim to facilitate the implementation of new adaptation technologies, increase agricultural productivity, and mitigate the impacts of climate extremes on crop production. By showcasing the potential of these approaches, this research contributes to the development of sustainable agricultural practices that can meet the demand for food. In conclusion, integrating agricultural practices with climate forecasting and EO technology can provide evidence-based and innovative solutions to the challenges of sustainable intensification.

Keywords: Drought, sustainable cropping systems, Remote Sensing

The Impact of Agri-Environment-Climate Measures on Farmland Biodiversity

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Agri-environment-climate measures (AECMs) are the main tools of the EU's Common Agricultural Policy to counteract the dramatic biodiversity decline and improve climate resilience in European farmlands. However, their effectiveness is repeatedly doubted because it varies when measured at the field versus landscape level and depends on the environmental and land-use context. Understanding what limits their effectiveness is thus crucial for developing management recommendations that maximize their efficacy. Here, we summarize results from the BESTMAP project (Horizon 2020), in which we investigated the effect of five groups of AECMs on the occurrence of indicator farmland birds in Germany and Czechia. To do so, we used ensemble species distribution models based on field-level data on cultivated crops, farmland management and implemented measures, and data on environmental conditions in the wider agricultural landscape. Moreover, we evaluated scenarios simulating how habitat suitability would change if AECMs were completely removed or, on the contrary, their adoption by farmers increased to meet conservation-informed targets. Our results indicate that the current level of adoption of AECMs delivers only modest gains in breeding habitat suitability. However, habitat conditions improved for the majority of species when the implementation of AECMs increased, suggesting that they could be effective conservation tools if higher adoption levels were reached. The heterogeneity of responses across species and spatial scales indicated that a mix of different measures, applied widely across farmlands, would likely maximize their benefits for biodiversity. This can be achieved only if the measures in the future policies will be cooperatively designed in a regionally targeted way to improve their attractiveness for farmers and widen their uptake.
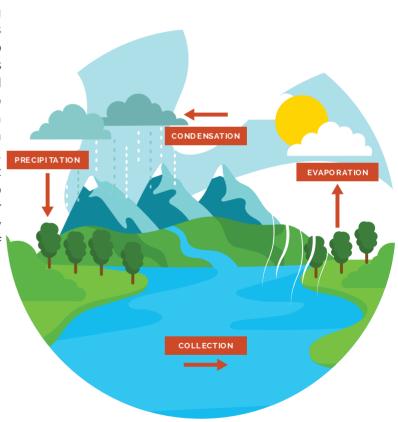
New Challenges for Restoring Wooded Meadows to Mitigate Climate Change

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The land use changes during 20th century had led to the disappearance of seminatural meadows. In 950ies there were 1,108,400 ha seminatural grasslands, most of them paludified and peatland meadows. Nowadays the national management plan of protected seminatural habitats sets a goal to maintain about 60,000 ha of meadows, but only 4.2 % of protected meadows have been paludified meadows. The species that depends on wet grasslands are disappearing rapidly. In order to maintain the biodiversity of wet grasslands, the use of peatlands should be intensified. Today the wooded meadows are maintained and restored mainly in mineral soils in western part of Estonia. Historically most of pastures and hay meadows were with sparse tree cover. For example, the study of agricultural records from 1939 demonstrated in test areas in Southern Estonia, that

28% of pastures and hay meadows were with trees. Today 84 % of fens in Estonia are drained, lost its natural water regime and are important carbon emitters. The land reclamation systems (4,500,00 ha in agricultural lands) that were established in Soviet Period, are amortized and land owners are interested to reconstruct them.   At the same time the Climate Policy in Estonia aims to neglect the peatlands and plant trees to the low-value farmland. Until now, wooded grasslands have been restored by thinning forested areas. The new approach of restoration basis on features of traditional wooded wet grasslands – to plant the deciduous trees on drained peat soils following the features of traditional wooded grasslands.   Such agroforestry practice allows to continue the use of drained fens without renovation the melioration systems, support the carbon sequestration and serve the habitats for biodiversity. The trees provide shelter for livestock in increasing hot summers, improve the water regime due to evaporation, increase diversity growing conditions for grass layer. The ecosystem services provided by drained peatland will increase which is the goal of modern intensification of land use.

CONDENSATION

PRECIPITATION

EVAPORATION

COLLECTION

Urban Agriculture in Bouaké: Offering a Varied Range of Short-Cycle Crops to Meet the Needs of City Dwellers.

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Agriculture is increasingly taking over the urban fabric of African cities despite the restrictions put in place to marginalize and exclude it. In sub-Saharan Africa, approximately 40% of urban households are engaged in agricultural activities in the city (FAO, 2012). In Bouaké, the second largest urban center after Abidjan, which has been ravaged by a decade of military-political crisis, urban agriculture is also growing. This is despite the lack of political recognition and land pressure due to the city's disproportionate expansion and transformation of the landscape. One only has to walk along the edges of arterial roads, on plots that have not yet been developed or are insufficiently developed, and in low-lying areas to see city dwellers involved in agricultural activities on a daily basis. In practice, the emphasis is on a diversity of short-cycle crops in order to contribute to the supply of fresh produce to a constantly growing urban population. This study therefore aims to highlight the contribution of urban farmers in Bouaké to food security after the military-political crisis that the country has experienced through varied agricultural production for a diversified food system. To this end, a literature review on urban agriculture and surveys of the various stakeholders formed the basis of our approach. The study shows that the diversity of crops grown in Bouaké contributes significantly to feeding the ever-growing population of Bouaké with fresh produce and offers a wider range of household food. The study also shows that urban agriculture is becoming increasingly organized in Bouake with the establishment of farmers' associations in the various neighborhoods.

Key words: Urban agriculture, supply, varied range, short-cycle crops, Bouaké

Contextualising household food insecurity: A comparison of two villages, Mnyamana (Alfred Nzo district) and Maramanzhi (Vhembe District), South Africa

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Smallholder crop production is a defining feature of achieving food security, particularly at the household level. However, the area of land where cultivation is practised in rural areas of South Africa is declining as households withdraw from field cultivation to home-gardening. While substantial efforts have been devoted towards assessing food insecurity in the country, the need to increase household food production demands attention. This paper presents results from a study conducted to determine the prevalence of household food insecurity in two villages, one located in the Eastern Cape and the other in Limpopo province. Semi-structured questionnaires were administered to acquire both qualitative and quantitative data from 106 heads of households. The IBM SPSS Statistics 28.0 computer

program was applied to complete data analysis. The findings of the study, analysed using the Household Food Insecurity Access Scale (HFIAS) indicated that food access challenges are a prevalent phenomenon among households as the majority of respondents were found to be mildly food insecure owing to food shortages emanating from insufficient income and waning crop production. Reliance on purchased food has negative implications for household food security but crop cultivation is adopted as a vital strategy for improving food availability and alleviating food shortages. Since deagrarianization erodes opportunities for increased smallholder production, enhancement of arable land needs to be central to policies addressing household food insecurity because the ownership of land has not guaranteed food security for the majority. In this regard, interventions extending beyond the provision of water, electricity, market access, skills and information could not only improve self-provisioning capacity but also make the prospects of achieving household food security feasible.

Markov Chain Modelling and Analysis of Land Use Dynamics in Lake Chad

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This study models spatiotemporal land-use dynamics in Lake Chad over two decades (2000 – 2020). Landsat 7 ETM+ satellite images for the years 2000, 2010, and 2020 were classified into several land use classes: Water, Reeds, and Archipelagoes or inundated lands that can be used for agriculture. The classification was done using a maximum likelihood supervised classification algorithm. Markov Chain models were created and used to simulate land use changes with the aim of prediction. Two state transition probability matrices were created from pairs of classified images 2000–2010, and 2010–2020. Between the years 2000 and 2010, 39.44% of the water surface area remained, 54.70% changed to reeds, and 5.86% changed to archipelagoes. 26.235 of the reed surfaces changed to water surfaces, 63.12% remained reeds, and 10.64% changed to archipelagoes. 1.70% of the archipelago changed to water surfaces, 4.46% turned to reeds, and 93.84% remained archipelagoes. Between 2010 and 2020, 28.79% of the water surface remained, 34.12% of the water surface turned to reeds, and 37.07% of the water surface turned to archipelagoes. 14.65% of the reed surface turned to water surfaces, 53.87% remained reeds, and 31.48% turned to archipelagoes. 0.98% of the archipelago surfaces turned to water surfaces, 4.88% turned to reeds, and 94.13% remained archipelagoes. These transition probability matrices were used to create Markov Chain models which were used to simulate land-use changes for the year 2010, with the year 2000 as the base year, and the year 2020 with the year 2010 as the base year. Projections were made for the years

2030, 2040, and 2050 and it shows that by the year 2050, more than 93% of the water surfaces will have changed to other land use classes. Restoration of vegetation cover around the lake is one way to help in mitigating the shrinking of the water surfaces.

Bottom-Up Approaches for Nature Positive - The Way of Co-Design and Co-Research

Funding Mechanism for Supporting Small and Medium-Sized Companies to Join Ecosystem Conservation in Local Cities in Japan

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The many challenges associated with climate change are having profound impacts on all business sectors. Economic systems are needed to be transformed to enhance the sustainable use of natural capital. The Task Force on Nature-Related Financial Disclosure (TNFD), launched in 2021 along with the movement toward "Nature Positive," forces global companies to disclose their contribution to natural capital and make investment decisions based on this information. In local cities of Japan, however, awareness of the crisis has not been widespread enough, because there are only a few global companies, and most are small and medium-sized companies (SMCs). The objective of this study is to identify financing mechanisms and the role of regional finance companies in supporting the participation of SMCs in ecosystem conservation in local cities. In 2015, the Japan Securities Dealers Association (JSCPA) created a new financial system, called "Shareholder Community (SC)". The SC aims to support the financing of growth companies and the promotion of community-based activities among SMCs. Transactions are limited to community participants. Securities firms designated by the JSCA examine companies that want to join the SC from the financial condition and ensure its accuracy. In Tokushima Prefecture, "Tokushima Godo Securities Co., Ltd." (TGS), which has a philosophy of contributing to the conservation of local biodiversity, has been designated as a securities firm. TGS certified Hiyori Farm, an organic JAS-certified agricultural corporation, as the first SC. The area where Hiyori Farm is located has been selected as one of the 500 most important wetlands in Japan by the Ministry of the Environment, and the rice paddies have functioned as alternative habitats for many endangered aquatic plants. Continuing rice cultivation leads to the conservation of those species, and thus TGS can contribute to the conservation of biodiversity by using the SC system.

Collaborative Management and Activities at Remnant Satoyama-Foreat Park in Kyoto City, Japan

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Takaragaike Park is an urban park located in the north of Kyoto City, Japan. The area around Takaragaike Park used to be a rural area, and the forests in the park were used as agricultural forests. Today, however, the area has become a near-urban forest due to the urbanization of the surrounding area. The forest is secondary vegetation that was established after human disturbance. However, the forest has been degraded due to reduced forest maintenance, feeding damage to plants by deer, and tree mortality caused by bark beetles. In 2008, the management of the park was

renewed, and a play park was started. The organizers of the play park have been practicing reforestation in cooperation with local residents' groups and landscape ecologists. Through these efforts, the Takaragaike Forest Conservation and Restoration Council was established, and several projects have been undertaken, including measures to prevent animal damage, forest conservation, and study sessions. What is noteworthy about this case study is the involvement of diverse actors, including environmental education, ecosystem conservation, local traditional culture, and academia (forestry and landscape ecology). Each actor has different motivations and is not necessarily working toward a single goal. However, by positioning the Takaragaike forest as an "urban satoyama," they are using the motif of satoyama to construct a vision and unite different activities. The management of the council is conducted as a transdisciplinary practice in which citizens and researchers collaborate, and through these activities, partnerships are also maintained with the city government and other public stakeholders. In this context, landscape ecologists not only support reforestation activities by assessing and mapping forest vegetation succession and deer feeding damage, but also play a diverse role in managing the council.

Local Collaboration for Sustainable Use of Local Common Species: An Example from Kyoto, Japan

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Non-timber forest products (NTFPs) are widely used in many communities. Although most of the production areas are in countryside near the forest, not a few of them are also consumed in urban area through trade routes. Kyoto is an ancient capital of Japan with one of the oldest histories continuing as metropolitan area today, and we can still find some local resource procurement system remaining from the past between the urban area and surrounding rural areas. A local variety of common bamboo species, "Chimakizasa" (*Sasa veitchii* var. *hirsuta*), is one of the examples. This species has been sustainably used for centuries in traditional rituals and cuisine in central Kyoto, including UNESCO intangible cultural heritage such as Gion Festival. After 2000s, however, the local resource supply chain collapsed due to sudden resource exhaustion caused by complex combination of recent changes in our society and nature. Even though they have some traits as local variety and special value for local community, it was difficult for this common species to be protected by national level programmes. Therefore, citizens started a bottom-up approach. Academia conducted ecological and social research on this species in accordance with the citizen's movement. In 2013, Citizens, local government, industry, and university formed a committee to co-work for conservation. The local government began to establish policies and action programmes using scientific knowledge from the universities, and Local Biodiversity Strategies and Action Plan has established in 2014 including the conservation of Chimakizasa. Japanese Ministry of the Environment also started financial support from 2021. These subsequent projects promoted the regeneration of resource on the site and the local people succeeded to restart harvesting from autumn of 2022. The recovery of

locally harmonious resource management will bring various positive effects for local ecosystem and community in the age of Nature Positive.

Emergent Process of Governance System for Restoring Unmanaged Ecosystem -Comparison between two Activities at Satoyama and Coastal Forests in Fukutsu City, Kyusyu, Japan

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For achieving 30by30, national and local biodiversity-strategy have been established in each country and region. Using private land is necessitated to reach the goal, and the key in the actual process is how diverse stakeholders collaborate in horizontal/non-hierarchical relationships. And hence finding a way to form local/community governance is important. In this study, we clarify the relationship between governance structure and the landscape attributes from the comparison of two local activities for restoring and conserving the forests in Fukutsu City, Kyushu, Japan. At the abandoned Satoyama forest in the mountain area, a restoration project has been started in 2017, initiated by the researcher-group (RG) to implement the biodiversity strategy of Fukutsu. The RG arranged with the landowner and called residents to collaborate, and then local people participated in the conservation works. Through the collaboration, the local people began to recognize the value of the Satoyama forest and the necessity of restoration activities. In this case governance system has emerged by the initiation of RG. At the coastal pine forest, the land is owned by governments and private, and the project has been initiated by members of the local community. Incentives of the activities come from people's memory of the past landscape and the thought of recovering it. The local council, which was established under the policy of Fukutsu City, took a role to share people's memories, recognize challenges and establish a goal in the local area. Fukutsu City has transferred authority and fiscal resources to the local council according to the policy on promoting local governance. It has successfully brought a governance-based solution to ecosystem management. Comparing the two projects, the governance structure is different, but it can be seen the common processes in sharing values among the member, and the emergence of horizontal/non-hierarchical network organization for managing the projects.

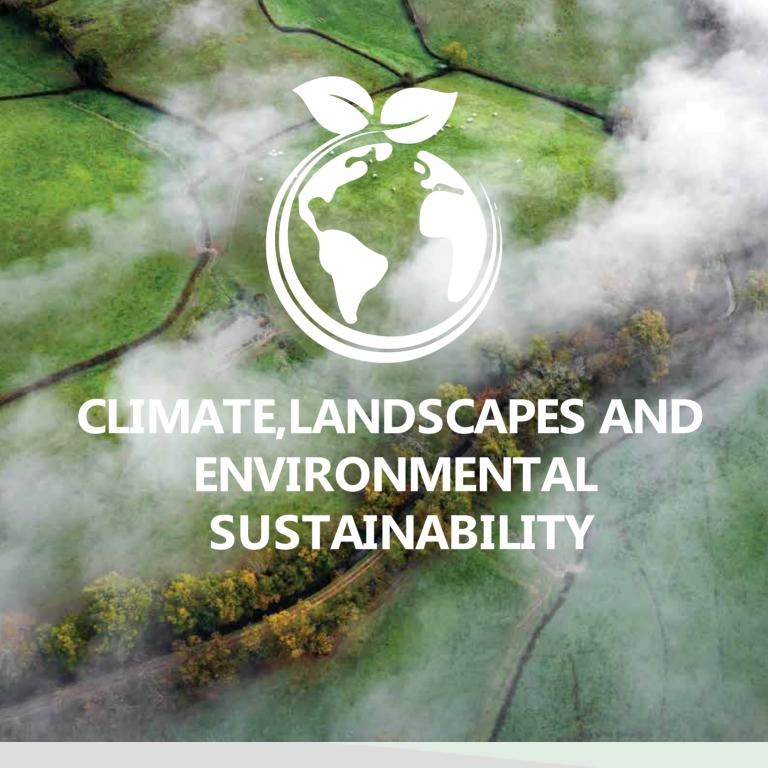## Nature-Based Solutions through Citizen Involvement in Coastal Area

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In many developed countries, aging and declining populations are becoming serious social issues. In Japan, the population began to decline after peaking in 2008, and the aging rate is 29.1%, one of the highest in

the world. On the other hand, Japan achieved remarkable economic development from 1950s to 1960s following World War II, when rapid population growth was accompanied by high-density urban development and social capital improvements such as road and railway networks. Now a days, many of these infrastructures have now become obsolete and need to be maintained and replacement. However, many municipalities face budget shortages due to population decline, making it difficult to replace aging infrastructure. Furthermore, in recent years, climate change has led to the frequent occurrence of extremely events caused of severe disasters that exceed expectations. Therefore, nature-based solutions (NbS), such as ecosystem-based disaster risk reduction (Eco-DRR) or green infrastructures, are now attracting attention. This presentation will introduce conservation activities by citizens for natural coast that have become endanger landscapes in Japan, as well as restoration and maintenance activities of natural ecosystems by local residents after the tsunami disasters. On the other hand, the lack of financial support and concerns about sustainable activities due to the aging of the population were cited as challenges for citizens' activities to maintain and manage natural ecosystems. However, it was suggested that activities could be incorporated into educational programs at elementary schools to ensure sustainability and spread to the local community through schoolchildren.

CLIMATE, LANDSCAPES AND ENVIRONMENTAL SUSTAINABILITY

Urban Resilience in Flood Prone Neighbourhoods of North Central, Nigeria

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Nigerian cities are ravaged by the negative impact of climate change. The effects of climate change result from climatic anomalies such as heat waves, water shortage and stress, drought and flooding. In North-Central cities of Nigeria, floods remain a threat to community's sustainability. This study assesses flood resilience in the north-central cities of Nigeria. The specific objective of this study was to examine the resilience efforts to flooding in cities of North-Central Nigeria. This was done through the systematic review of literature on flood and urban resilience in the study region. The study reveals that uncoordinated urban planning, lack of political will to follow through infrastructural development planning in the cities understudy threatens urban resilience to flooding. Thus, recommends an inclusive planning approach that strengthens communities' capacity and ability to flooding management.

Projecting Future Impervious Fraction in Urban Landscapes Under Alternative Socioeconomic and Climate Scenarios with Implications for Water Resources

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The fraction of impervious cover on developed land has important implications for ecological resilience in urban landscapes because the provision of ecosystem services, including water quality and quantity, depends on land cover type and condition. As income and population grow and urban land use expands, so too will the amount of impervious surface. However, the degree to which new development will add impervious cover and how that impacts water provision remains uncertain. In this study we examined how future scenarios of development, driven by population, income, and climate projections, affect the imperviousness of urban landscapes at the small watershed scale across the conterminous United States (U.S.). Using empirical model estimates we project future impervious cover for 20 alternative climate and socioeconomic futures for combinations of two radiative forcings (RCPs) and four socioeconomic pathways (SSPs). Total impervious area is projected to increase through 2070 under all scenarios; however, SSPs with relatively higher rates of socioeconomic change led to greater projected

increases in average impervious fraction. Projections for average impervious fraction on developed land in 2070 range from 29.6% (2% decrease compared with 2020) under climate models in the low-growth SSP scenario to 34.2-34.6% under a high-growth SSP scenario (15% increase), and a total increase in impervious area of 53,700 to 84,400 km^2 (50-78% increase) compared to 2020. We also find notable regional differences where average impervious fraction is projected to decrease in the Pacific Coast region of the western U.S. under all scenarios, suggesting that new development will be less impervious than the current average. We demonstrate application of our results by identifying watersheds where impervious cover could exceed thresholds for water quality and aquatic biological integrity. We discuss implications for sustainability of urban landscapes and the ecosystem services they provide.

Impact of Abandonment and Grazing on Ground Beetle Assemblages in the Baltic Sea Coastal Grassland-Forest Ecosystem

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The main aim of the study was to analyze the impacts of abandonment and grazing on the distribution of ground beetles in the coastal grasslands-forest ecosystems. The study area was located within the west coastline of mainland Estonia (between 57.3° and 59.5° N and 21.5° and 28.1° E) in Northern Europe, covering two different landscape regions. The study included sites managed by grazing and abandoned sites from the margin of the coastal grassland-forest ecosystem. The pitfall traps were used for collecting specimens of ground beetles: four traps in the open grassland, four traps in the forest and two traps in the margin were buried at the ground level in each study site and were left for four effective days in July-August 2021. Ground beetles were collected, stored, and identified at the species level. The data were analyzed in R using a general linear model and ANOVA to compare factors and their interactions, the estimated marginal means for multiple comparisons and the "indicspecies" for species relationships. Results showed that grazing-managed grasslands had significantly higher abundance, species richness, and diversity of ground beetles compared to abandoned grasslands, especially in the Gulf of Livonia coastal lowland region. Indicator species varied by management scheme in both regions. The most common species found in all sites was a large carnivore and a generalist species, *Pterostichus niger*. Although there were abandoned coastal grasslands with smaller assemblages and less species-rich of ground beetles, the pan-European nature conservation Natura 2000 network and the incentives for land management contribute positively to the species richness of ground beetle assemblages. Our study provides valuable insights into the effects of abandonment on ground beetles and highlights the importance of land management in maintaining the biodiversity of ground beetles in coastal grasslands-forest ecosystems. However, further analysis of the environmental parameters is recommended.

Strengthening Coastal Ecosystem Resilience by Multiple Zonation for Conservation, Restoration and Climatic Adaption

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Coastal wetlands function as key socioeconomic resources as well as ecological barriers for sustainable development in coastal regions. Although previous research and practices indicate that restoration of degraded wetlands needs the combination with intact natural wetlands to achieve the best integrated ecosystem services, this kind of integration still lacks both research and practice. In the past decades, increased land reclamation coupling with climate change (e.g., sea level rise) have led to considerable coastal squeeze effects and intensified degradation and loss in coastal wetlands along Chinese coastline, and restoration of damaged coastal wetlands is therefore urgently needed to enhance the overall ecological functions of coastal wetlands and to strengthen the coastal resilience under coupled human-natural stresses. Here, a framework of "three-line integration" spatial strategy is conceptualized to develop ecological security pattern of coastal wetlands in China. The proposed spatial strategy emphasizes the establishment of an integrated coastal ecological security pattern by delineating RGB (red-green-blue) multiple zones in which red-line area (remaining nature habitats) is prioritized for coastal wetland conservation, incorporating with green-line area (impaired habitats with high restoration potential) reserved for urgent restoration and blue-line area allocated for adaption to long-term sea level rise. In addition, some related issues covering coastal wetland conservation and restoration, wise land use, and sustainable development were discussed.

Assessing the Impact of Copper Mining Pollution-Induced Environmental Stress on Miombo Woodlands: On the Growth and Wood Characteristics of *Brachystegia Longifolia* Benth Naturally Growing in A Copper Mining Environment of Mufulira, Zambia

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Emissions from industrial activities, including mining, contaminate soils in the surrounding forests. These emissions contain potentially toxic elements (PTEs), harmful to plants at varying concentrations. The effect of PTEs on plants depends on several factors, including plant species. This study investigated the impact of

copper mining-pollution-induced environmental stress on miombo woodlands with a special focus on the effect of metal phytotoxicities on the growth and wood characteristics of *Brachystegia longifolia* Benth naturally growing in the area surrounding a mine in the Copperbelt region of Zambia. A characteristic species of the miombo woodlands, *Brachystegia* is of high commercial value and widely distributed in Zambia, Zimbabwe, Tanzania, Malawi, Mozambique, Angola and the Democratic Republic of Congo. These are all mining countries, where mining activities are located within or near forests. *B. longifolia* wood is used for structural purposes, energy generation and furniture manufacturing. However, the effect of PTE-induced stress on the growth and wood quality of this tree species is not well established. Tree ring width, wood density and cell dimensions were determined and compared between wood extracted from *B. longifolia* growing in an uncontaminated (19 km upwind) and contaminated site (2 km downwind). A significant reduction in the radial growth of *B. longifolia* was observed on a contaminated site. A multivariate analysis attributed the reduction in tree growth to Fe and Cu toxicities, suggesting that *B. longifolia* trees accumulate and tolerate Zn and Mn. A comparison of the wood structure between a polluted and a control site confirmed radial growth reduction on the contaminated site, attributing it to decreased wood cell dimensions. Furthermore, an increased basic density of 0.61 g/cm^3, as opposed to 0.52 g/cm^3 at the control site was recorded, representing a 17 % increase. The increased wood density at the polluted site was attributed to the lower tree growth rate and elevated levels of heavy metals in the annual rings. This study shows that copper mining-induced environmental stress alters the quality of *B. longifolia* wood, affecting forest productivity and compromising the sustainable utilisation of this and possibly other miombo woodland tree species naturally growing in metal-polluted environments.

An Integrated Multi-Way Feedback Dynamics Model for Assessing Eco-Environmental and Socioeconomic Impacts of Invasive Insect Pests in Eastern Africa

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Insect pests pose significant challenges and have detrimental effects on agriculture, ecosystems, and economies in Africa. Their ecosystems are complex agro-ecologies that involve multiple interacting components and processes. The complexity arises from various factors, including the diversity of insect pests, their interactions with other organisms, and the dynamic nature of their habitats. Therefore, a system dynamics modelling approach was implemented to comprehensively understand the multifaceted impacts of insect pests and their natural enemies. This modelling approach allows for a more in-depth representation of each of the individual components of the whole system. Specifically, we applied a system dynamic model to

assess the interactions between the invasive fall armyworm and stemborer pests in the cereal agroecosystems in Africa. We commenced with a causal loop diagram, known as a conceptual model, to map the different variables of a whole system and model the feedback, non-linear effects, and delays, which are then translated into stocks and flows diagrams for quantifications and simulations. The model was further coupled with a rule-based model to access the socioeconomic impacts of desert locusts at a landscape scale. The results showed the co-existence of fall armyworm with stemborer species as an additional pest to cereal crops across different agroecological zones. This interaction should be considered when developing integrated pest management strategies to combat these two pests. For desert locusts, the results demonstrated that these invasive pests extensively contribute to slowing down of current and future farming expansion and reducing food production leading to increased food insecurity at different magnitudes at a landscape level across different East African countries.

Keywords: Landscape; agro-ecologies; system dynamic; impact assessment; invasive insects

Why Transboundary Natural Resource Management and Adaptation Do Matter for Environmental Sustainability and Human Well-Being in the Greater Horn of Africa Rangelands? An Insight from Ethiopia-Kenya Borderland

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This article examines the need for transboundary natural resource management and adaptation for environmental sustainability and human well-being. This work was based on empirical evidence obtained from Ethiopia-Kenya borderland; it contributes to the understanding of the need for transboundary natural resource management and adaptation in the Greater Horn of Africa states where large numbers of pastoral communities live crossing international boundaries. The Greater Horn of Africa states share not only borders but also people speaking the same language, sharing common tradition and culture, similar ecology and similar mode of life–pastoralism. We used a qualitative approach in which in-depth interviews, focus group discussions and field observations were used as methods of data collection. The finding of the study indicates the Ethiopia-Kenya borderland is highly susceptible to overexploitation of natural resources. Climate change and human interference have caused rangeland degradation. The findings contribute to the understanding of the Great Horn of African states borderlands which suffer from environmental degradation and poverty. The degradation of environmental resources in the border area and overexploitation of the natural resources in the face of climate change strongly requires regional cooperation and integration for natural resource management and adaptation so as to deter further degradation, to maintain degraded lands and improve the wellbeing of the people living in there. Thus, the transboundary cooperation for transboundary natural resource management and adaptation is strongly required to bring the people and institutions together to avert common challenges of rangelands degradation, to control animal diseases, and bush encroachment.

Therefore, the two governments in particular, the Greater Horn of African states in general should demonstrate political commitment to adopt a harmonized rangeland policy and well-coordinated joint efforts to solicit resources to combat climate change and environmental shocks related challenges and problems.

Soil Organic Carbon and CO2 Efflux Under Different Grazing Intensities in Miombo Woodland in Tanzania

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Healthy soil is fundamental for the world's ecosystems supporting millions of communities in the world. However, increased livestock grazing remains a threat to soil resulting to increased soil heterogeneity, compaction, and soil erosion which lowers soil health and productivity. Despite this, few studies have documented the effect of increased grazing intensities on soil health in Miombo woodland. Understanding this, is important for proper soil management, productivity, and ecosystem functioning as a whole. Therefore, this study aimed at assessing the varying pattern of soil C and CO_2 efflux under different grazing intensities in Miombo woodlands in Tanzania. Data were collected from nine (9) selected forests found in Kilosa, Kilombero and Handeni districts covering the whole miombo biome found in the country. A total of 198 plots were used to assess SOC and CO_2 efflux. A closed chamber system by EGM-5 CO_2 gas analyzer was used to measure Soil CO_2 efflux in the field. The number of livestock per area and scoring method approaches were used to quantify different grazing intensities. Results revealed that there is a significant difference (p=0.00010) in SOC and CO_2 efflux between high and light grazing intensities. The study found a negative relationship between high grazing intensity and SOC (%) and a positive trend was observed within the medium grazing intensity. We conclude that, increased livestock grazing significantly lowers soil stability to store C however, light grazing intensity or restricting grazing activities may trigger soil capacity to store more C.

Changing Land Use in The Sudd Wetland in South Sudan, and Implications for Community Livelihoods

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The Sudd in South Sudan, formed by the White Nile's Bahr al-Jabal section is one of the largest and most important wetlands in the world. The communities depend on the Sudd wetland both directly and indirectly for livelihoods for fisheries, grazing and farming land. Furthermore, wetlands are among the most productive life support systems and are critical in maintaining biodiversity. In Jonglei State, climate variability and change has led to flooding of the Sudd wetland, with both positive and negative effects on the community livelihoods. This paper presents an analysis of land use change in the Sudd wetland and implications on community livelihoods. Landsat and Sentinel images for 1990(92), 2000(02), 2010(12) and 2020(22) were used in the analysis. The different land use types were categorized into water bodies, forests, grassland, croplands, wetlands, shrubland, riverine, built-up areas, bare land. ESA/USGS/Earth Engine was used in the data analysis. The analysis indicates that over the period 2000 to 2022, there has been an increase in the both the water body and the Sudd wetland, while the shrubs and grasslands have decreased. Indeed, the Sudd wetland increased in 2022 by more than 50% of its land surface of 2000 in the wet season. It is noted that due to flooding, the wetland can now only be accessed by boat, thus affecting the livelihood activities of the communities, including farming, fishing and grazing of livestock.

Runoff Modelling Using SCS-CN And GIS Approach in the Chennai Tamil Nadu

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Runoff modelling is an essential aspect of water resource management and flood mitigation.
In this study, we have employed the SCS-CN (Soil Conservation Service Curve Number) and
GIS (Geographic Information System) approach to model the runoff potential of Chennai,
Tamil Nadu. We have created a land cover map and a soil map using remote sensing data and soil surveys, respectively. CN values have been assigned to each land cover and soil type, and the average CN value has been calculated for the study area. The SCS-CN formula has been applied to estimate the runoff for a given rainfall event, taking into account rainfall intensity, duration, and antecedent moisture conditions. The GIS approach has been used to perform all the necessary calculations and mapping tasks. The findings of this study can be used to inform water resource management and land use planning in Chennai and other areas with similar characteristics. The SCS-CN and GIS approach can be a useful tool for assessing and managing the potential for surface runoff and infiltration in urban and rural areas Runoff modelling is an essential aspect of water resource management and flood mitigation. In this

study, we have employed the SCS-CN (Soil Conservation Service Curve Number) and GIS (Geographic Information System) approach to model the runoff potential of Chennai, Tamil Nadu. We have created a land cover map and a soil map using remote sensing data and soil surveys, respectively. CN values have been assigned to each land cover and soil type, and the average CN value has been calculated for the study area. The SCS-CN formula has been applied to estimate the runoff for a given rainfall event, taking into account rainfall intensity, duration, and antecedent moisture conditions. The GIS approach has been used to perform all the necessary calculations and mapping tasks. The findings of this study can be used to inform water resource management and land use planning in Chennai and other areas with similar characteristics. The SCS-CN and GIS approach can be a useful tool for assessing and managing the potential for surface runoff and infiltration in urban and rural area

Characterizing 3D Urban Growth in the City of Wuhan Using Time-Series Building Data

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Urban densification and outward expansion are two manifestations of urbanization. However, the spatiotemporal evolution of urban densification has been poorly understood. This study, using time-series building data covering the period of 2000 – 2018 in central Wuhan, is thus focused on this aspect of urbanization. We first show that building height, density, and volume increased substantially in this largest metropolis of Central China. However, building height in the urban core areas was usually smaller than the surroundings, while building density displayed a radial pattern with city center having the highest density. Second, multivariate clustering analysis was conducted to recognize five types of urban morphological zones. Type I (i.e., the highest density with medium height) was enlarged considerably around the city center from 2000 to 2018. Type IV (i.e., maximum height with high density) signified the most developed built-up areas, and it was increasingly found across the central Wuhan but not necessarily in the urban core areas. Frog leaping was the dominant urban expansion form in the early stage of urbanization, while infill and edge-expansion forms were prevalent during 2012 – 2018. Among the frog-leaping types, distant leap accounted for the largest proportion, followed by close leap. Finally, a positive spatial autocorrelation was found between building density/volume and the POI density. The high-high matched areas were found in the urban core areas, while the low-low matched areas mainly appeared in industrial zones. Findings of this study help a comprehensive understanding of urban land-change process, and have practical implications for sustainable urban landscape planning to promote synergies between urban structures and human activities.

The Concept of a Multiple-Scale Analysis of the Polish Ecological Network and Evaluation of the Changes in its Landscape Structure after the 2000s

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The ecological network of Poland is a complicated system of protected areas that aims to preserve the country's most valuable natural and semi-natural ecosystems, which cover about 32% of its land area, managed by the central and regional authorities (Poskrobko & Poskrobko, 2012; Macias et al., 2020). Considering the pilot character of the studies and Poland's specific environmental management system, all the detailed analyses were performed on the selected study area, the Greater Poland Province, and its 35 counties. The importance of ecological networks is constantly arising due to landscape fragmentation and anthropogenic environmental changes connected to intensifying land use policies. One of the crucial problems in conservation planning is landscape fragmentation, which opposes the persistence of biodiversity (Montoya et al., 2006; Groves & Game, 2016). Following the EU Biodiversity Strategy for 2030 (European Commission, 2020), healthy ecosystems need to allow migration and prevent the genetic isolation of species. The primary goal of our study was to conceptualize the analysis of the Polish ecological network, which would help identify its structural problems using a specific set of landscape metrics. Regarding conservation areas, there are different needs in the planning and decision-making of central and local authorities. Our research included country-wide, regional, and local scale analyses. On the poster, we presented the developed procedure scheme of the study, including all the methods and specific GIS tools used. Its essential part was selecting the source data and its processing. As a result, we compared the differentiation of the results using a few data sets, i.e., Corine Land Cover (CLC), Topographic Objects Database (BDOT10k), and our data based on the orthophoto maps of the study area. Therefore, we also could present how the specific data resource and its quality influenced all the calculated landscape metrics and results of the conducted landscape analyses.

Prediction of Tsetse Fly (*Glossina Spp*) Habitat Suitability in Kenya Using a Species Distribution Modelling Approach

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Vector-borne diseases (VBDs) threaten human and animal health and account for more than 17% of the neglected tropical diseases (NTD) transmission across continents. In Kenya, tsetse fly (*Glossina spp*) is the common vector that is responsible for the transmission of animal African trypanosomiasis (AAT), affecting 38 counties in the country. To avert location-specific risks, machine learning modelling approaches are necessary to characterize ecologically suitable landscapes for tsetse fly occurrence and distribution. Therefore, this study aimed to predict suitable habitats for tsetse fly

occurrence in Kenya utilizing fine to medium satellite-based climatic and landscape structural variables, and a generalized linear model (GLM). We employed a GLM model using 1479 tsetse fly occurrence data points. Our model achieved an accuracy of 0.87 for predicting tsetse fly distribution in Kenya. We found that land surface temperature, normalized difference vegetation index, soil moisture, sand content and cattle density had the highest contribution to the model performance. The findings of this study were operationally used to guide the surveillance of tsetse fly presence in Kenya.

Keywords: Species distribution; landscape ecology; vector-borne disease; animal health; Kenya

Testing the Sentinel Method: Alive Prey Produce Better Estimates of Predation Intensity than Plasticine Models Across Urbanization Gradients

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The sentinel method has been widely adopted to quantify predation intensity by establishing patches of prey (commonly worm-shaped insect prey resembling a caterpillar) and recording the rate of disappearance or traces of predation after a certain period of exposure. However, many studies use plasticine caterpillar models, which might substantially underestimate predation intensity. Plasticine models do not move and lack chemical cues so they likely are less attractive to predators. Here, we designed an experiment across a rural-to-urban gradient in Suzhou (East China) combining alive prey and plasticine models to show that alive prey should preferably be used to obtain accurate estimates of predation intensity. More specifically, we released 2575 plasticine models and 3825 alive preys in 10 natural, rural and urban locations around Suzhou. Our results show that predation rate using plasticine models was remarkably low and did not respond to habitat changes, while predation rate using alive prey considerably increased across the habitat transformation gradients reaching 82.14% on average in urban locations. Our results suggest that plasticine models produce unrealistic estimates of predation intensity and, while they might be used as a fast-screening tool, alive prey should be employed in comprehensive studies on this fundamental ecosystem service.

Keywords: ecosystem services, plasticine models, predation, sentinel method, urbanization

Nonparametric Assessment of Mangrove Ecosystem in the Context of Coastal Resilience in Ghana

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In this study, geographical data on mangrove ecosystem was quantified, simulated and evaluated using relevant models. The evaluation was conducted with the help of google earth engine (GEE) and InVEST model. The GEE platform was utilized to track changes in mangrove cover relative to other land cover types for the years 2009 and 2019 by integrating synthetic aperture radar (SAR) and optical satellite data. The ecosystem structural aspects such as canopy height and Above Ground Biomass (AGB) density were assessed using GEE for the year 2000 and validated with a field

work conducted in 2020. The InVEST model was used to calculate a hazard index of every 250m of the shoreline with and without mangrove ecosystem. This index demonstrated the role of mangrove ecosystem as a robust nature-based solution to coastal resilience. Between 2009 and 2019, mangrove and other vegetation cover decreased by roughly 16.9% and 21%, respectively. While water bodies and bare/built-up areas expanded by 7% and 45%, respectively. Overall classification accuracy for 2009 and 2019 was 99.6% and 99.1% respectively. Mangrove height and above ground biomass generally decreased from 12.7– 6.3 m and 130– 88 kg/ha on average. The vulnerability index showed that 76% and 23.5% of the coastal segment in the presence of mangrove fall under low and moderate risks respectively. Whereas in the absence of mangrove, 44%, 50% and 6% fall under low, moderate and high-risk zones respectively. Undoubtedly, the study demonstrated that there is the need to enhance conservation practices in coastal management.

Keywords: Coastal vulnerability, Coastal defense, Complex wetland, Ghana, Hazard index, LULC

Kenya's Rift Valley Lakes Level Rise Potent an Ecological Disaster and Anthropocene Vulnerability: Case Study of Lakes Baringo and Bogoria

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Climate change has crippled transboundary ecosystems with impacts on ecologies and socio-economic set-up. Although Kenya's rift valley lakes have experienced fluctuations over geological time, the lakes showed significant water level rise linked to climate variability in the last decade. Increased discharge into Lakes Baringo and Bogoria led to consequential ecological deterioration and impacts on livelihoods. This study focused on understanding landscape dynamics, drainage patterns, flow regimes and biodiversity loss to assess ecological footprints. It also examined multidimensional consequences of the lakes level rise on the Anthropocene: agriculture, infrastructure, tourism, and settlements. We used satellite-based data at various time-steps i.e., 2010, 2014, 2018, 2020 and 2023 to assess inundation levels and analyze ecological impacts. In situ observation were conducted in 5 time periods: 2010, 2013, 2017, 2020 and 2022 alongside key informant interviews from relevant sectors. Our results indicated a decreasing biomass after submergence following inundations. Also, an impending disaster from invasive *Prosopis julifora* that was persistent in flooded areas, invading crop- and grasslands, thus jeopardized human livelihoods. Topographic analysis showed a possible merging of the two lakes, at a scaling of 3m between the maximum spread of the two lakes,

threatening an ecological disaster. Lake Baringo (969m asl) flooded southward, and Lake Bogoria (991m asl) northward, to about 12.73km apart (2020) from 23.19km (2010). 3,087 households, 139.98km² of arable land, 11 hotels, 24 schools, 6 hospitals and 40km of road network were affected. Increased cases of social decay: unwanted pregnancies, sexually transmitted diseases, sexual and gender based-violence along with waterborne disease and human-wildlife conflict were on the rise. The tourism industry suffered significant losses. These findings would inform planning for climate change mitigation, livelihood and habitat restoration, and guiding policy formulation on climate change-based impacts.

Keywords: landscape dynamics; hydrological modeling; climate change; biodiversity; conservation; human-wildlife conflicts

Study on the Spatial-Temporal Driving Mechanism of Landscape Pattern on Habitat Quality in the Surrounding Area of the Mountainous National Park

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National parks are among the most biodiversity-rich areas within protected areas worldwide. Recently, China has been developing the world's largest national park system, with a focus on high-quality construction of mountainous national parks due to their unique topography and ecological sensitivity. However, previous studies have overlooked ecosystem connectivity and paid insufficient attention to the impact of landscape patterns on habitat quality in the surrounding areas of national parks. In this study, we propose a new research method for landscape ecology using a multi-scale geographically and temporally weighted regression (MGTWR) model. We apply this model to investigate the spatial-temporal driving mechanism of landscape patterns on habitat quality in the conservation and development zone of Wuyishan National Park, using land use data from 1980 to 2020. We calculate regional landscape pattern indices using Fragstats and evaluate regional habitat quality using the InVEST model. Our results indicate that, in the past four decades, the habitat quality of cities and counties in the conservation and development belt of Wuyishan National Park has shown an overall declining trend, particularly from 2000 to 2010. Although the overall fluctuation of landscape patterns is small, we found significant differences in urban centers, suburbs, and rural areas. Specifically, PD and CIRCLE_MN are significantly negatively correlated with the quality of urban center habitats, while CONTIG_MN has a positive effect on the quality of rural habitats. SHDI has a positive impact on suburban habitat quality and a negative impact on rural habitat quality. Moreover, our study reveals that the spatial-temporal effect of landscape pattern on habitat quality exhibits significant heterogeneity and that the MGTWR model is effective in explaining this effect. This study is of great significance to avoid the islanding of national parks and promote the sustainable development

Understanding Social-Ecological Sustainability of Urban Landscape, From a Prospective of Urban Parks' Health Benefits in Beijing, China

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The rapid urbanization with consequent land-use change and ecosystem degradation have caused various environmental problems, and lead to the progressive separation of urban residents from nature. Faced with enormous challenges on public health, urban green space planning interventions have emerged as an important issue and nature-based solution for sustainable development of cities, especially in high-density urban areas. However, few studies have focused on the role of urban parks in affecting health outcomes and the differences among population groups. Considering the area proportion of total green spaces and urban parks within different spatial scales, and different urban park distribution characteristics including availability, accessibility, and attractiveness, this study attempted to understand the associations between urban parks and self-reported health of urban residents, and to identify the variation among population groups. Based on a series of spatial explicit assessment and multi-regression analyses, results showed that the area proportion of urban park was more significant than that of total green spaces in affecting health outcomes, no matter in neighborhood or sub-district scales. Among various dimensions of urban park distribution characteristics, accessibility was found to have more significant impacts on health outcomes than availability and attractiveness of urban parks, especially for the elderly group. To create healthy and equitable settlements, these findings suggested that planners and managers should give urban parks extra priority in green space decision-making, and provide more conveniences for the vulnerable groups to access parks. Further research into exploring the assessment of different planning-related urban park distribution characteristics, and associations between different urban park types and health outcome could provide more exact and practical information for planners and managers.

Keywords: Urban green space; Spatial pattern; Self-reported health; Vulnerable groups; Social equality.

Terraced Landscapes as Great Human Footprints Benefit Ecological Civilization and Sustainable Development

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Terraced landscapes, considered as coupled human and natural systems, have played crucial roles in eco-services and sustainable developments for millenniums. However, precise quantifications of terrace pattern and multiple benefits at different scales remain challenge, especially in the context of global change. Based on remote sensing, field monitoring, meta-analysis and data-integration methods, we have developed several approaches on terrace distribution, and clarified the roles of terracing in erosion control, soil water recharge, drought resistance, nutrient retention and vegetation restoration during past years. The key advances are as

follows. First, we selected several loess hilly watersheds in China to detect how terraced landscapes were distributed and used over time and space, and to develop techniques regarding terrace extraction and recognition. Such methods are mostly based on land use map, topography features, machine learning and algorithms. Second, we conducted many field plots to monitor how terracing structures affect soil and water conservation, vegetation growth and succession in water-restricted loess regions. It was found that terracing can reduce runoff and sediment yield at least by 42% and 73% respectively, with zig terraces more powerful than level ditches, shallow benches and fish-scale pits. Terracing also increases soil moisture and sap flux by 15% and 25% in such regions. We also collect national and world-wide data to quantify multiple effects of terracing on ecosystem services. Facing key challenges such as terrace abandonment and collapse risks, more efforts regarding these issues should to be made, aiming for achieving wiser managements and sustainability of such unique landscapes.

Exploring the Relationships Between Local Participation and Perceived Co-Management Performances: Evidence from China's National Park

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Understanding local perceptions is essential to secure the proper functioning of co-management in protected areas. However, scientific investigations have virtually ignored the quantitative assessment of the extent to which shall locals be empowered to ensure optimistic judgements towards co-management. Against this background, this paper seeks to investigate the effects of varied participation types and levels on perceived performances in a centralized co-management regime in Giant Panda National Park, China. Using 17 semi-structured interviews and 353 survey questionnaires, our research identified six co-management subtypes, classifying into four empowering levels: instructive, consultative, agreement and cooperative degrees. Surprisingly, the multivariable analysis points to a very sobering fact that the involvement in the equally cooperative level (type) is not significantly linked with more favorable perceptions. In contrast, local residents engaged in the lowest instructive level of co-management (supportive, training, and employment subtypes) are inclined to develop positive attitudes across ecological, social and livelihood dimensions. This study has come up with a succinct conclusion that merely empowering locals might not facilitate perceived successes among local dwellers, and the enforcement of instructive co-management intending to enhance local well-being is commendable, particularly in a top-down co-management regime. In addition, this paper advocate for more attention to increasing the livelihood impact of co-management policies, especially for the low-income, elder, and less educated groups residing around China's national parks.

Keywords: Protected Areas (PA), Community, Co-management, Local Empowerment, Effectiveness, Perceptions

Determinants of the Characterization of Vineyard Landscapes for the Initiation of Ecological Viticulture in Tunisia

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The question of the vineyard landscape is not recent, its qualification and promotion is the object of new concerns. The evolution of this landscape is still poorly understood and needs to be clarified in order to elaborate coherent strategies for planning and sustainable development. The policy in this field requires instruments and methods at different scales, which are both prospective and participatory. The fields of geographic information systems (gis) are currently in full development and propose a better solutions for landscapes characterisation and solving their problems. The present study is situated at the articulation of landscape research and the development of gis applied to the vineyards of boukornine protected area. The main result of this study consists in the proposal of a participatory approach of multiscale diagnosis of the vineyard landscape, which is based on different deterninants, on the specific use of qgis and on the participatory approach. Moreover it presents objectively the results of subjective landscape perceptions and offers an interesting basis for the negotiation of the promotion of ecological and sustainable viticulture and the preservation of the patrimonial vineyard landscape.
Keywords : Vineyard landscapes Determinants, GIS approch, Ecological viticulture, Boukornine protected area.

Tree Management Plan Using GIS Technology. A Case Study in District 1, Bucharest, Romania

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Trees produce numerous benefits for people and nature, especially in urban environments affected by pollution from vehicles, construction sites and more, but as climate change progresses, ensuring a sustainable landscape management will become increasingly important. Dendrological vegetation improves air quality and human wellbeing, with multiple beneficial purposes such as removing air pollutants, filter stormwater, trees can cool down areas which are typically warmer due to hard surfaces, act as a natural barrier, support health and so on This study examines the trees from District 1, Bucharest, Romania, using data science and geospatial technology. As the town continues to expand, it is important to evaluate the urban tree canopy data, in order to be able to prioritize tree planting. Additionally, vegetation indices are used to quantify greenness, show vegetation density and changes in plant health. Trees from main roads and boulevards in District 1 were monitored using GIS

(Geographical Information System), along with satellite image analyses and band combinations methods to visualize data in a convenient way to generate valuable insights. These tools can accelerate the tree assessment, while this type of data collection guarantees a more efficient workflow and better data quality. For the results and discussion phase, recommendations were made to support the long-term maintenance of these trees. Thus, the phytosanitary issues were centralized to prevent human and material damage, while a management plan was drawn up with specific interventions. The management plan includes a tree species selection guide based on anticipated climate change conditions. This assures that the species with bad health can be slowly replaced with better adapted species to the urban conditions. Last, but not least, an urban tree management plan and maintenance can be very useful to provide an optimal density and distribution, as an essential part of green urban strategies.

Enabling Nature-Based Pest Control Solutions through Landscape-Scale Mango (*Mangifera Indica* L.) Orchard Detection Using Sentinel-1 And -2 Satellite Variables in a Semi-Arid Environment

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Creating tree-crop maps requires fine spatial and temporal resolution imagery to discriminate the rapid transitions in tree phenological and spectral features. Freely accessible satellite data of relatively high spatial and temporal resolutions affords opportunities for wide-area land use and land cover (LULC) mapping, including tree-crop. This study combined the capabilities of Sentinel-1 (S1) and Sentinel-2 (S2) variables (n = 81) to widely map mango orchards in Zimbabwe using machine learning classifiers, i.e., support vector machine and random forest. Reference data were collected on mango orchards and other LULC classes. Fewer variables were selected from 'All' combined S1 and S2 variables using three commonly utilized variable selection methods, i.e., relief filter, guided regularized random forest, and variance inflation factor. Several classification experiments (n = 8) were conducted using 60% of field datasets and combinations of 'All' and fewer selected variables. The experiments were compared using the remaining 40% of the field dataset and the area underclass approach. The analysis outcomes proved that the amalgamation of random forest and relief filter selected variables outperforms (F1 score > 70%) all other variable combination experiments. The mapping precision of the mango orchards was more than 80% for each of the eight classification experiments. Results revealed that mango orchards occupied approximately 18% of the spatial extent of the study area. Furthermore, S1 variables were constantly selected compared with the S2-derived variables across the three variable selection approaches used in this study. The study demonstrated that the use of multi-modal satellite imagery and robust machine learning classifiers can accurately detect mango orchards and other LULC classes in semi-arid environments. These results can be used for guiding and upscaling nature-based pest control mechanisms for

managing mango insect pests such as the devastating invasive fruit fly *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae).

Wetland Landscape Management: from Theory to Practice

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A new concept, the regional pattern for ecological security, was proposed based on adaptive ecosystem management (KM MA 2004). Which is a new methodology for landscape planning, other than the IL McHarg (1969) Pancake planning based on ecological suitability of fields, EP Odum(1969) Ecosystem development strategy based on ecosystem dynamic analysis, and RTT Forman(1995) Landscape planning based on spatial pattern optimization, we promoted the landscape planning from Function-Process-Pattern to Management. Then a case study was conducted by using multiple water resources, enlarging wetland areas, improving water bird habitats, and promoting ecosystem services in the Yellow River Delta, China.

Remote Sensing for Bio-Cultural Heritage Preservation in An African Semi-Arid Region: A Case Study of Indigenous Wells in Northern Kenya and Southern Ethiopia

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The region of Southern Ethiopia (Borana) and Northern Kenya (Marsabit) is characterized by erratic rainfall, limited surface water, aridity, and frequent droughts. An important adaptive response to these conditions, of uncertain antiquity, has been the hand-excavation of a sequence of deep wells at key locations often along seasonal riverbeds and valley bottoms where subterranean aquifers can be tapped, resulting in a distinctive form of bio-cultural heritage. These systems, are increasingly under threat, however, from climate change, demographic growth, and socio-economic development. To contribute to an assessment of the scale, distribution and intensity of these threats, this study aimed to evaluate the land-use land-cover (LULC) and precipitation changes in this semi-arid to arid landscape and their association with, and impact on, the preservation of traditional wells. Multi-temporal Landsat 5, 7 and 8 satellite imagery covering the period 1990 to 2020, analyzed at a temporal resolution of 10 years, were classified using supervised classification via the Random Forest machine learning method. Change detection was then applied to identify and quantify changes through time and landscape degradation indices were generated using the Shannon Diversity Index fragmentation index within a 15 km buffer of each well cluster. The results indicated that land cover change

was mostly driven by increasing anthropogenic changes with resultant reduction in natural land cover classes. Our approach showed that remote sensing methods can be used for the spatially explicit mapping of landscape structure around the wells, and ultimately towards assessment of the preservation status of the indigenous wells.

Resistance and Resilience of Hyrcanian Mixed Forests Under Natural and Anthropogenic Disturbances

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Biological disturbances are integral to forest ecosystems and have pronounced effects on forest resistance, resilience, and diversity. The Hyrcanian mixed forest, in northern Iran, is at risk of declining resistance, resilience, and diversity due to ongoing pressure from land use change, harvesting, and biological disturbances. We analyzed the resistance and resilience of this area under two biological disturbances (i.e., oak charcoal fungus, *Biscogniauxia mediterranea*, and alder leaf beetle, *Galerucella lineola*) and in concert with proposed harvesting. We used a simulation modeling approach whereby we simulated 12 combinations of biological disturbances and harvesting scenarios using the LANDIS-II landscape change model. We estimated the correlation between forest resistance and resilience and tree species diversity to harvesting and biological disturbance. We analyzed the full species composition and age class for 30 and 100 years after disturbances in order to assess resistance as the change in species composition over time. We considered resilience as the ability to recover from a disturbance back to a similar initial state. Results indicate a positive effect of biological disturbances and harvesting on diversity. Our simulations resulted in a negative relationship between diversity- resistance and diversity-resilience within high diversity areas. Our simulation of the Hyrcanian forest reveals that harvesting and biological disturbances, as tested, fulfill the goal of maintaining forest diversity. However, increasing diversity does not always follow by increasing forest resistance and resilience. Scenarios with oak charcoal fungus, both with and without harvesting indicate the lowest decrease in resilient and resistant.

Assessment of the Size and Distribution of Wild Areas in Poland

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In recent years, more and more attention has been paid to protecting and restoring wildlife. Wilderness areas are not explicitly mentioned in the EU Birds and Habitats Directives, but applying a wildlife-based approach to the management of Natura 2000 sites is seen as being in line with the provisions of these Directives. In addition, scientific evidence shows that wilderness areas are resilient to pressures affecting biodiversity and should be considered as an essential tool to help

achieve biodiversity goals. Protecting biodiversity, these areas provide a whole range of ecosystem services and are their reservoir in the event of various ecological disasters. These areas deliver an essential ecosystem service by maintaining nursery populations and habitats. The guide: "Guidelines on Wilderness in Natura 2000" distinguishes two categories of wilderness areas - wilderness and wild areas. For this study, the following definition of wild nature areas was adopted: forest areas of a natural character, located far from road infrastructure and buildings, with an area that allows them to be shaped exclusively or almost exclusively by natural biological processes. The study aims to designate wilde areas and assess their share in other protected areas, especially Natura 2000. To complete the objective, the following indicators were selected and counted: 1. undisturbedness (distance to the buildings, roads, and railways), 2. naturalness (habitat status N1 in polish forest management manual), 3. largeness (area > 5000 ha and 2000-5000 ha if surrounding of the forest is semi-natural). The results help to designate twenty areas of wild nature in Poland. They are all located within Natura 2000 areas, mainly PLB. Their total area is 1285 km2, which is 1.17% of the forest area in Poland and 0.41% of Poland's territory.

The Analyses of Land Cover History on Protected Areas for Effective Nature Conservation

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In Estonia, a relatively large proportion of the protected areas territory is privately owned. Therefore, involvement of local residents and landowners in nature conservation activities and landscape management is very significant. A dozen years ago, it was recognized that effective nature conservation requires more detailed land use planning at the landscape level. The managers of the protected area emphasized the need to compile a database of land cover changes in order to better communicate and involve local residents. The studies of historic land cover change were carried out between 2010 and 2022 in eight protected areas, including five national parks, in Estonia. The historical land cover changes and persistence of the types of land cover over the past 120 years were analyzed in GIS. By comparing historical topographic map layers land cover change scenarios were derived. Due to the landscape's complexity and mapping methods used, different land cover change scenarios in one protected area could reach hundreds of thousands. We faced the challenge of grouping similar land cover developments, discovering that the logic that works for one protected area may not work for another. Considering site-specific conditions, historical land use patterns and socioeconomic developments, land management classes were elaborated with suggestions to incorporate them into protected area management plans. The analysis and management suggestions were discussed with managers of protected areas and introduced to local communities to achieve reconciliation of social, environmental and biodiversity goals. Interpreted historic land cover change data provides valuable input also for land use planners or

those involved in landscape decision-making at different scales.

Visualizing Conflicts Between Terrestrial Biodiversity Conservation and Renewable Energy Potential in Japan

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30 by 30 is an essential goal for biodiversity conservation, while decarbonization requires a renewable energy (RE) installation on land. However, the unmanaged introduction of RE will cause trade-offs with the local biodiversity conservation through the alteration of habitat for wildlife and collision with wildlife. This study visualized the trade-offs at the national scale in Japan by overlaying spatial distributions of vegetation, birds, bats, and the potential of REs for the land areas. This study developed a database comprising indices of ecological data and RE potentials at 500 x 500 m. For the ecological indices, we referred to the selection criteria of OECM (Other Effective area-based Conservation Measures). The landscapes with high importance for conservation were evaluated by the amount of natural and secondary ecosystems; the spatial distributions of important species for conservation were evaluated by the breeding information of birds registered in the Red List and a diversity map of bat species. The potentials of solar, wind, hydropower, and geothermal powers, and woody biomass energy were collected from a previous study. The results showed that 65.1% of the land areas in Japan had conflicts between biodiversity and RE. The types of conflicts differed, reflecting local ecosystems: e.g., 1. high solar power and important birds; 2. high wind power and important bird and bat species; 3. high woody biomass and traditional secondary landscapes; and 4. high solar power and traditional secondary landscapes. These results can support the appropriate zoning of REs introduction that can achieve regional biodiversity conservation and decarbonization.

Problems of Organizing the Ecological Framework of Urbogeosystems of Siberia on the Example of the Regional Center of Irkutsk

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Currently, the city as a complex system has certain patterns of formation and development under the influence of both natural and anthropogenic factors. Thanks to the natural subsystem, urban areas are involved in global biogeochemical cycles and, therefore,

are such a part of the geographic envelope as the urban geosystem. The paper deals with the organization of the ecological framework (EC) of modern cities as a necessary element of the urban geosystem. The development of tools for adapting technogenic human life to the natural one at this stage of the development of society is positioned as the most important task of modern urban planning. Particular attention is paid to the study of the structure and configuration of the ecological framework. The territory of Siberia is more than half of the area of Russia. Siberian urbogeosystems are represented by such large regional centers as Krasnoyarsk, Tomsk, Tyumen, Kemerovo, Irkutsk, etc. Common to these cities is their position in the forest zone of the temperate zone, industrial specialization, the history of the development of settlements, which fits into the more than 300-year period of the development of Siberia, population in excess of half a million. The city of Irkutsk, a regional center of the Irkutsk region, a subject of the Siberian Federal District of the Russian Federation, where the share of the urban population is over 77%, was chosen as a model territory. A cartographic model of the ecological framework of the city of Irkutsk has been created. Using the QGIS toolkit and satellite images of the Global Forest Change service, data on the vegetation cover of the city were obtained. The configuration of the ecological frame was characterized on the basis of taking into account the dimension of the EC elements, the dispersion and localization of the EC elements relative to the center-periphery of the city, the location of the green elements relative to the main water artery of the city. Based on the analysis of this information, it was found that the spatial organization of the ecological framework of the city does not meet the requirements for the sustainable development of urban systems, and also does not fully satisfy the needs of the population in obtaining high-quality ecosystem services. The main problem is the structural imperfection of the eco-framework, which manifests itself in the "breaking of ties" of green elements. This is partly due to a historical factor: the settlements that are currently the regional centers of Siberia developed spontaneously over a period of more than 300 years, which was reflected in the formation of a mixed configuration of the ecological framework. At the present stage, it is quite difficult to resolve these contradictions; it is necessary to improve the regulatory legal acts of the Urban Planning Code of the Russian Federation that regulate the development of the ecological framework.

Innovative and Adaptive Urban and Peri-Urban Agriculture: A Tool of Building Resilience and Enhancing Food Security in Kenya

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Urban agriculture is likely to become a major contributor to food security for urban residents in third world countries, who are projected to comprise more than half of the world population by 2050. Food

production within urban homesteads and community gardens provide several potential benefits including; building economical resilience, enhancing nutrition, reducing ecological footprints, and improving environmental habitability. In order for urban agriculture to be sustainable, several food production challenges must be addressed including; limited farming space, novel climatic conditions associated with urban heat island effect, handling solid waste, water insecurity, waterborne diseases, air and water pollution. Through a systematic literature review and observation method, we explore the various innovative and adaptive farming techniques used by urban and peri-urban farmers in Kenya and discuss the potential economic, social and environmental benefits of urban agriculture in the country.

Keywords: Urban agriculture, Food insecurity, Community gardens, Sustainable

Spatially Heterogeneous Effect of Temperature on Electricity Consumption

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The relationship between electricity consumption (EC) and temperature (T) influences the energy supply-demand balance within cities, and a non-linear EC-T relationship has been widely documented at a city scale, but few studies have investigated the spatial variations of such relation at the intra-urban scale. Here, we choose Shenzhen, a megacity in a subtropic climate as a case study, to quantify the EC-T relationship from the city scale to the within-city scale, based on population and building footprint data with land use features. The city-scale EC-T relation was fitted by segmented regression models, and the effect of humidity, air pollutants and holidays were considered. Then it was extrapolated to a grid scale of 12m × 12m, using a population and floor area weighting method. First, we found the EC-T relationship varied greatly by sector at the city scale. Domestic EC was the most strongly influenced by temperature, increasing by 23.4%/°C and 24.9%/°C after 23.6°C and 28.8°C. Industrial EC increased by 3.9%/°C when the temperature was higher than 20°C. Commercial and public EC were subject to similar effects of temperature when the temperature exceeded 20.8°C, growing at a rate of 9.5%/°C and 10.9%/°C, respectively. Second, large intracity spatial variations in the relationship were found, with the rate of change of EC varying from 0 to 4.7 kWh/m2/°C. On average, the slope of commercial grids was greater than that of residential grids, at 0.05 and 0.04 kWh/m2/°C, while variations were larger in the commercial zone, with a coefficient of variation of 2.4, and only 1.1 in the residential zone. Comparing the proportion of the temperature-sensitive electricity consumption to the total electricity consumption (TECP), we found it varied from 9.7% to 49.4% in space, with most of the high values occurring in residential grids, indicating the priority locations for urban cooling and energy savings.

Land Use Dynamics and Its Impact on Soil Properties; A Case Study in a Micro Watershed in the Blue Nile Basin

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Land use change has become a major environmental and economic problem that significantly affects soil properties and nutrient dynamics. This study aimed to evaluate the impact of land use land cover (LULC) changes on soil physicochemical properties in Cheliya watershed over a period of 40 years. Time series satellite images and ground truth data were used to detect changes, while soil samples were collected from forest, grazing, cultivated, and shrub lands. Analysis of data was accomplished through the integrated use of ERDAS Imagine 2018 and ArcGIS 10.8. The results showed significant LULC changes in the past 40 years, with forest and shrub lands experiencing a reduction, while cultivation and grasslands increased. Soil analysis results also showed significant variations in soil properties due to LULC successions. Soil properties such as clay, silt, and sand fractions, bulk and particle density, total porosity, moisture content, pH, electrical conductivity, organic matter, total nitrogen, available phosphorus, cation exchange capacity, phosphate buffer capacity, exchangeable bases (Ca^{2+}, Mg^{2+}, K^+), and exchangeable acidity (H^+) were significantly higher in forest land. However, the carbon-to-nitrogen ratio and exchangeable acidity contents of both cultivated and grazing lands and the exchangeable Na^+ value of cultivated land were not significantly different from their concentration observed in forest land. The study concluded that forests and shrub lands were most at risk of LULC changes in the study area, and the influence of LULC changes on most parameters was negative on the soils of cultivated and grazing lands.

Therefore, appropriate and integrated land management options for different LULC types are required to sustain agricultural productivity while protecting the environment.

Colonial Narratives and Global Environmental Discourses and Practices in the Post-Colonial Africa: The Case of the East African Community

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Active politically-inclined environmental discourse as discussed by a number of writers is seen to have begun a little over four decades ago, while other writers would argue that it all began at the wake of European colonialism, which varied in different countries and regions. Given the broad nature of this subject and myriad arguments and views that could be presented while discussing the historical emergence of environmental discourses, I will confine my arguments to the period beginning with European colonialism. This paper provides an in-depth analysis of the relationship between colonialism and the environment in Africa, alongside an evaluation of global environmental discourses and practices in relation to the continent. It discusses the challenges and opportunities for environmental sustainability in post-colonial Africa, with a focus on the East African Community (EAC). It will provide recommendations for future research and action.

Keywords: Colonialism, Environment, Africa, Post-colonial, Sustainability, Research

An Assessment of Ecological Niche Dynamics Between the Native and Introduced Ranges of Invasive Plants

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Plants, including food and economic crops, have been moved beyond their natural ranges for many centuries. Many of these exotic plants have contributed immensely to food security and socioeconomic aspects of the receiving regions. However, some of them have become invasive, with significant ecological and economic impacts in their introduced ranges. This study investigates niche overlap, stability, and expansion of five selected plants with Neotropical origin but invasive in Nigeria. This include *Chromolaena odorata, Spermacoce latifolia, Prosopis juliflora, Sida rhombifolia*, and *Mimosa pudica*. These five selected plants represent different life forms including herb, tree, and shrub, for comparisons. We downloaded and cleaned occurrence data for these five invasive plants both in their global native ranges and invasive distributions from the Global Biodiversity Information Facility (GBIF) database. We extracted climatic data associated with these occurrence points from five uncorrelated ($r>0.6$) WorldClim bioclimatic variables (30 arc seconds), and used niche centroid, overlap, unfilling, and expansion (COUE) framework to assess niche differences between the native and invaded ranges of the invasive plants. Preliminary findings show that all five invasive plants have significantly high niche overlap between their native and invaded climatic niches. We also observed marginally significant niche expansion in the herbaceous invasive plants compared to the shrub and tree. These results point towards niche conservatism despite range expansion for these Neotropical plants. We discuss the implication of these results in the light of globalization and climate change.

Urban Expansion Weakens the Contribution of Local Land Cover to Urban Warming

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Previous studies have shown that urbanization process affects urban temperature from the local scale to the city scale. For example, changes in the structure of cities during urban expansion affect energy exchange processes, leading to a higher temperature in the core area than that in the outskirts. At the same time, differences in the composition and configuration of land cover between blocks, neighborhoods, and communities significantly influence local climate. Numerous studies have investigated the respective impact of urban expansion and local land cover on urban warming, however, their relative contributions

and whether/how they change over time were unaddressed yet. Here, we identify annual land cover changes and urban boundaries in Beijing from 1985 to 2018, using time-series impervious surfaces data. We further examine the effects of the city-scale and local-scale factors, as well as their interactions on the annual and seasonal air temperatures using multiple linear models, based on daily temperature data from 14 National Meteorological Observing Stations. We found urban expansion and local land cover change jointly affected urban warming, but their relative contribution changed over time, showing the occurrence of three turning points. The first one occurred at the city size of 976 km^2, before which the local land cover change was the predominant factor contributing to urban warming. Both factors significantly affected the mean temperature with city size growing from 976 km^2 to 2272 km^2, showing the relative importance of the local factor decreased, while the relative importance of the city-scale factor continued to increase, and became greater when the city was larger than 1646 km^2. The local factor did not play any significant role when the city area exceeded 2272 km^2. Notably, turning points usually occur when small urban patches are contiguous. Results can provide insights on urban planning for heat mitigation and adaptation.

Importance of Urban Green Spaces Conservation in Providing Ecosystem Services and Climate Change Mitigation in Developing Countries

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Urban green spaces (urban forests, urban parks, garden parks, sacred forests, roadside trees...) throughout their conservation play a high role in human well-being and welfare by mitigating climate effects. This is because of their capacity to exchange solar radiation from the sun that is transformed in CO_2 to freezing and fresh air fulfills of oxygen. These urban green spaces help with land conservation and stability and also with climate amelioration. Ecosystem services provided by urban green spaces are vital for humans in urban regions. Large and contiguous core nature areas, smaller green areas and ecological connections between them are the essence of regional ecological networks and are essential for maintaining interconnected habitats for species and thus biological diversity. Thus, both local and regional level ecological networks are vital for maintaining ecosystem services in urban regions. However, urban development through urbanization poses a great problem for the ability of urban green spaces to be conserved. The expansion of urban cities has resulted in the fragmentation of urban green spaces from rural green area. This phenomenon is still ongoing toward the cities. In that case, it is almost impossible for human to benefit of ecosystems services provided by urban green spaces. The impacts of climate change coupled with land-use and land cover change will bring serious challenges for maintaining urban green spaces and thus ecosystem services in urban areas. Indeed, despite its importance, urban green spaces faced a numerous pressure from those it protects. A numerous of people do not care about the benefit resulting of urban green spaces. This because there is a lack of information on ecosystem services of urban regions and there is a need to enhance the knowledge for cities development planning. The results of this project will

help decision-makers and populations to take a good conservation strategy plan into the urbanization process with the purpose of climate adaptation and mitigation.

Estimating the Contribution of Roadside Trees to Environmental Sustainability in the City of Limbe in Cameroon Using I-Tree Eco

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African cities are expected to be highly urbanised by 2050. Population increases intersecting unplanned urban development that characterise this region will exert pressure on pre-existing environmental challenges like flood, landslide, heat, pollution and water scarcity. Urban forests are a critical and functional form of green infrastructure which has the power to tackle rapid urbanisation and guarantee environmental sustainability in cities through the provision of ecosystem services, but they are sometimes not considered in urban planning in African cities. The goal of this study was to estimate the contribution of roadside trees to climate change mitigation in the coastal city of Limbe in Cameroon. The city of Limbe has been facing recurrent floods and landslides caused by its coastal nature and poor drainage. Specific objectives include identification of roadside species composition (exotic versus local), evaluating their contribution to flood management, carbon stock and sequestration. Data collection and analysis was done by applying i-tree eco v6.0.32 a software design by the U.S Forest Service to assess urban forest ecosystem services. Roadside trees were surveyed for the entire Limbe municipality and parameters such as tree species type, diameter at breast height, crown height were measured. A total of I964 roadside trees with DBH≥30cm were identified which can store 4.641 000 metric tons of carbon (465005.87USD) and sequester 47.47metric tons of co_2 (476.71 USD) from the atmosphere. Avoided runoff was estimated as 7.488 000 metric tons/year (17730.44 USD). Exotic tree species were more common than local species. Availability of this type of scientific information on the cost-effective contribution of roadside trees to climate change mitigation can increase awareness of climate benefits of trees and promote the incorporation of urban forest nature-based solutions in strategic urban planning for sustainable cities.

Keywords: sustainable cities; Urban Forest ecosystem services; i-tree eco; Limbe; climate change mitigation

Earth Observation and Insects: Using Satellites and Drones to Monitor the Diversity of Insects, their Habitat Status and Colony Strength in Africa

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Global change effects will adversely influence insect habitat availability and contribute to the declines of insect diversity. This will have trickle-on effects on the ecosystems services they provide. Decision makers can increasingly use the vast amounts of Earth Observation (EO) information to assess and monitor insect-based (bio-)diversity. Moreover, the spatial and temporal metrics from EO can be effectively used to discern insect habitat zones. Coupled with land use or other information on human impact, the conservation status of specific species (e.g., Red list species) can be effectively estimated over wider areas. This is important information towards addressing several of the Aichi Biodiversity Targets (e.g., Targets 12 (Preventing Extinctions) and 14 (Essential Ecosystem Service for pollination). This contribution synergizes recent publications that use EO for insect biodiversity and habitat mapping. The publication survey shows the information depth gained when making use of multi-sensor fusion and various data dimensions. Moreover, from the assessment results, a conceptual framework was derived that illustrates how biodiversity status indicators can be computed from EO data, that best fit insect-specific physiological traits. Using an example, it is illustrated how EO information can be specifically and effectively used to monitor insect (bio-)diversity and the conservation status of their habitats on landscape scales. This was possible using several insect taxa and over various climate zones in Africa. In another example, it is shown how EO-predicted fragmentation information can be useful for assessing bee colony strength in Kenya.

Keywords: Biodiversity reporting; pollinator diversity; Earth Observation; landscape integrity; Africa

Ecological Landscape Characteristics and Protection Strategies in the Lower Yellow River, China

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Relying on the field investigation, remote sensing data and spatial analysis, a comprehensive feature along the yellow downstream ecosystem was advanced at first: 1) typical wandering river caused by the instability of channel, 2) the mutation of coming water and sediment on downstream caused disruptive effect on the river wetland; 3) artificial intervention has changed the ecosystem and biodiversity of the downstream river. Secondly, the problems threatening ecological security in the Yellow River region were summarized. 1) Flood control of the lower Yellow River has fixed the boundary and main functions of the ecosystem in the lower Yellow River; 2) The wandering downstream channels and the complex evolution of hard-hard boundary channels pose unique risks to river ecosystems and habitats; 3) The productive development and utilization of artificial irrational beach area changed the evolution direction of the downstream ecological landscape; 4) The establishment of various types of protected areas effectively alleviates the dilemma of downstream ecological protection. Subsequently, in order to meet requirements of the National Strategy for Ecological Protection and High-quality Development of the Yellow River Basin, it is suggested that the ecological protection strategies: 1) integrating existing types of protected areas and establishing a natural protected area system

dominated by national parks; 2) Relocating and constructing tidal area residential areas in combination with rural revitalization planning, restoring river water and wetland system; 3) strictly limited/low-impact development/LID, scientifically protecting downstream natural landscape system; 4) Cooperate with upstream and downstream water resources management to ensure sufficient water supply for the lower reaches and realize the health of the whole Yellow River.

Fragmented Landscapes Affect Honeybee Colony Strength at Diverse Spatial Scales in Agro-Ecological Landscapes in Kenya

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Landscape fragmentation and habitat loss at multiple scales directly affect species abundance, diversity, as well as their productivity. There is a paucity of information about the effect of the surrounding landscape structure and diversity on honeybee colony strength in Africa. The present research presents new insights into the relationship between landscape metrics such as patch size, shape, connectivity, composition and configuration and honeybee (*Apis mellifera*) colony strength characteristics in a typical highly fragmented African agro-ecological region in Kenya. Remote sensing-based landscape variables were linked to in situ determined honeybee colony strength variables using a unique data integration approach. The research was done within six sites of varying degrees of land degradation (LD), during the period from 2017 to 2018.

Landscape structure was first mapped using medium resolution bi-temporal Sentinel-1 and Sentinel-2 satellite imagery with an optimized random forest mapping algorithm and fragmentation metrics derived for the apiary buffer zones. The results of linear mixed effects models showed that honeybee colony strength increased with higher semi-natural landscape homogeneity, represented by lower Shannon Diversity Index (SHDI) as well as higher proportion of croplands at short distances from the apiary (<= 1 km), while lower complexity of patch geometries represented by Fractal Dimension (FD), resulted in higher colony strength at longer distances from the apiary (2 km). Honeybees in moderately degraded landscapes demonstrated the most consistently strong colonies throughout the study period. Our results demonstrated that honeybee colony strength is influenced by landscape fragmentation at diverse spatial scales in African agro-ecological landscapes. Efforts geared towards improvement of beekeepers' livelihoods through higher hive productivity should consider landscape fragmentation characteristics at various distances from apiaries. Moreover, beekeeping efforts should be targeted at moderately degraded and heterogeneous landscapes, which avail forage from diverse land cover types.

Profiling the Climate of Tanzania for Climate Change Mitigation and Adaptation

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With 12 agro-ecological zones, Tanzania is not homogeneous from a climatic point of view. Principally each zone has its own diverse and variable climate patterns depending on location. While regional climate models predict future rainfall increase across the country, the situation may not be true at local scales thus influencing the approaches to climate change management. Literature review and analysis of over 4-decade climate data from Tanzania Meteorological Agency representing the 12 agro-ecological zone show great variability in trends across the country. The seasonal rainfall patterns in the bi-model zones shows a mixed decreasing and increasing trend in March, April, May (MAM) and October, November and December (OND) seasons. The MAM rainfall showed increasing trend in zones 1, 2 and 3. The northern coast showed a slight increasing short rains and significant increase in long rains. The other zones show decreasing seasonal rainfall trends. The unimodal zones where the major rain season is OND show an increasing rainfall trend. The other zones show decreasing rainfall trends, with zone 5 showing a relatively constant rainfall. The number of rain days show a decreasing trend, the rainfall start date has shifted forward and the cessation dates have shifted backwards meaning that the growing season has shortened, and also shifted over most parts of the country. Generally, the maximum and minimum temperatures have increased by about $1^0C - 2^0C$ across the country. The probability of dry spells increased have increased as well. Such shifts have implications on decisions regarding crop establishment especially the planting dates and types of crops to plant. These trends and location specific variations call for specific climate change adaptation and mitigation measures. Given this situation generalized approaches to climate change mitigation and adaptation should be avoided in favor of specific actions in specific regions/zones.
Key Words: Agro-ecological zone, Climatic zone, Climate Change

Local Structural Factors Determining Seasonal Variability and Interannual Dynamics of Phytoproductive Functioning in Temperate Steppe Landscapes

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A detection relation between functioning parameters and [lan1dscape] spatial pattern is an insufficiently explored problem in modern landscape ecology. Landscape functioning depends on many factors which vary depending on the scale. Climate is a major limitative factor in temperate steppe landscapes. While some sources demonstrate that the topography and landscape pattern have an impact on functioning particularly phytomass and primary productivity. The study purpose was to identify focuses with different phytoproduction from the background and to determine the factors defining differences. We examined two model areas on the Tarkhankut Peninsula and the

Kerch Peninsula which located on the western and the eastern edges of Crimea, respectively. Feather grass steppes with forb on carbonate soils over limestones are located on both areas. The most significance have the territories of nature park "Tarkhankutskiy" and nature reserve "Osovinskaya steppe" where sites of pristine steppes are protected. Combination of multispectral images OLI-TIRS Landsat 8/9 and own field observations from the six transects allows to make a wide coverage of spatial relationships and to verify the results. Comparison of above-ground phytomass and NDVI values showed a reliable result for applying NDVI in our spatial model (correlation coefficient r=0.58). We measured NDVI-level for the beginning, middle and the end of growing season since 2014 to 2022 and derived the models of "hot and cold spots" based on Getis-Ord Gi* statistics. The spatial pattern creates exceptional local conditions with the formation of an atypical landscape functioning. Permanent clusters of "hot and cold spots" exist every observation date despite the amount of annual rainfall (for example, the valley of mud volcanoes near Kerch). Focuses of increased phytomass have a pulsating effect on surrounding landscapes in different seasons as the wash network on Tarkhankut prolongs the growing season in neighboring landscapes.

Production of Biodiesel from Parkia Biglobosa Oil Using Heterogeneous Bi-Functional Clay Catalyst

Rogers   Kipkoech[1]

[1]Kenyatta University, Kenya

The aim of this study was to produce biodiesel from edible *Parkia biglobosa* oil using heterogeneous bi-functional Na_2CO_3-clay catalyst. Soxhlet extraction method was used to extract the oil from *Parkia biglobosa* seeds and the percentage yield of oil determined to be 16.5 %. The oil contained 0.61% w/w free fatty acid (FFA) and 191.65 (mgKOH/g) saponification value, determine the suitable catalyst used for the production of biodiesel. Subsequently the oil was subjected to transesterification to biodiesel using the H_2SO_4 and bi-functional clay mineral or catalyst. The properties of the biodiesel were analysed using gas chromatography mass spectrometry (GC-MS). Catalyst synthesized from clay was slightly acidic with the PH of 4.88. The prepared catalyst was characterised by means of FTIR, SEM, UV Spectrum, EDS, and XRD. The efficiency of the catalyst for production of biodiesel was proven by the results of the transesterification study. The percentage weight of yield of biodiesel produced were 93.4 % and 94.7 % at optimal parameter of 6:1 and 12:1 methanol to oil molar ratio, 3 wt % and 2 wt % catalyst concentrations, 65℃ and 60℃ reaction temperature, 1.5 hrs reaction time for H_2SO_4 and bi-functional Na_2CO_3-clay catalyst transesterification. The biodiesel produced were within the limits of specification given by the American standard, test method (ASTM D6751), and European Standard (EN 14241**)**. Among the recommendation, the study suggest further research on ways of reducing iodine value and water content which were the only properties beyond accepted limit.

Assessment of the Harvest-Based Initiative in Tanzania's protected areas: management and Challenges

Jovine Nachihangu[1], Catherine A. Massao[2], Cuthbert Nahonyo[3], Upendo Richard[4], Khalfani Kiondo[5]. Floravick Kallambo[1]

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Harvest-Based Initiatives (HBI) are the sustainable use of wildlife resources by the local community, including fishing, beekeeping, local hunting, and other wildlife resources, to raise their standard of living and reduce unlawful activity in protected areas. However, despite their promise for long-term conservation and supporting human livelihoods, HBI is less famous in many protected areas in Tanzania. Therefore, this study investigates the implementation of the harvest-based initiatives in the Ugalla game reserve, its management and its challenges. Data were collected using a semi-structured interview questionnaire. A total of 141 trade union members were subjected to an interview. General characteristics of respondents, Criteria for joining a Trade Union, participation in HBI and challenges facing management of HBI were the types of data collected. The results indicate statistically significant involvement of the trade union members in decision-making. Furthermore, the survey found a strong correlation between trade union membership and decision-making satisfaction. Also, trade unions can exclude individuals from accessing or using wildlife resources once a member fails to implement the directives. Furthermore, it was revealed that corruption, the closing of fishing camps, poaching, change of game reserve managers, hunting companies and awareness of game reserve laws are challenges facing HBI inside Ugalla Game Reserve.It can be concluded that local communities set HBI participation conditions, disqualify people who lack legal access to and usage of wildlife resources in their territories and negotiate with game management to resolve problems over wildlife resources use. Second, ethnically homogeneous groups are more likely to follow norms, taboos, traditions, and historical context for wildlife resource management to support local livelihoods. Therefore, we strongly urge the Ministry of Natural Resources and Tourism to adopt a regulation to manage local community use of wildlife resources inside protected areas to improve livelihoods and acceptability.

Keywords. Community participation, management, wildlife, and Harvest-based initiatives

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Assessment of the Harvest-Based Initiative in Tanzania's Protected Areas: Management and Challenges

Jovine Nachihangu[1,2], Catherine A. Massao[2], Cuthbert Nahonyo[3], Upendo Richard[4] Khalfani Kiondo[5]. Floravick Kallambo[1]

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Harvest-Based Initiatives (HBI) are the sustainable use of wildlife resources by the local community, including fishing, beekeeping, local hunting, and other wildlife resources, to raise their standard of living and reduce unlawful activity in protected areas. However, despite their promise for long-term conservation and supporting human livelihoods, HBI is less famous in many protected areas in Tanzania. Therefore, this study investigates the implementation of the harvest-based initiatives in the Ugalla game reserve, its management and its challenges. Data were collected using a semi-structured interview questionnaire. A total of 141 trade union members were subjected to an interview. General characteristics of respondents, Criteria for joining a Trade Union, participation in HBI and challenges facing management of HBI were the types of data collected. The results indicate statistically significant involvement of the trade union members in decision-making. Furthermore, the survey found a strong correlation between trade union membership and decision-making satisfaction. Also, trade unions can exclude individuals

from accessing or using wildlife resources once a member fails to implement the directives. Furthermore, it was revealed that corruption, the closing of fishing camps, poaching, change of game reserve managers, hunting companies and awareness of game reserve laws are challenges facing HBI inside Ugalla Game Reserve. It can be concluded that local communities set HBI participation conditions, disqualify people who lack legal access to and usage of wildlife resources in their territories and negotiate with game management to resolve problems over wildlife resources use. Second, ethnically homogeneous groups are more likely to follow norms, taboos, traditions, and historical context for wildlife resource management to support local livelihoods. Therefore, we strongly urge the Ministry of Natural Resources and Tourism to adopt a regulation to manage local community use of wildlife resources inside protected areas to improve livelihoods and acceptability.

Need for Structured Conservation Inputs: An Approach for Landscape Prioritization to Restrict Disturbance Regime in the Rajaji-Corbett Landscape of the Western Himalayan Region

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The population boom increases land-use requirements and minimal shrinking regions are available to preserve natural biodiversity. Unfortunately, scientific knowledge does not seem to have and might never get a correct solution to how much territory will be sufficient for satisfying the various biodiversity conservation goals. Prioritization of habitat, primarily for threatened species, is a critical management challenge. Habitat management efforts are gradually being performed over broader geographic regions, emphasizing the necessity of spatial and strategic prioritization. Habitat prioritization is a technique popular for identifying critical areas needing conservation initiatives. To develop a strategic conservation framework, key issues must be identified based on the ground knowledge and present land use status, which are difficult to gather for highly rough terrain areas. Incorporating spatial data sets thus helps to get the desired knowledge of the site on a large scale. In this study, we took a grid-based multicriteria approach to create a spatial conservation management framework for the Rajaji-Corbett landscape (RCL), Northern India. A grid-based prioritization assessment was conducted to identify priority areas for the RCL keeping invasive species and fire as a significant threat. The indicators or criteria were selected by looking at present vital concerns in the landscape. We took 20 indicators for our multicriteria assessment for landscape prioritization of RCL using 2x2 km grids for the evaluation and classified them according to low, medium, and high priority areas using ArC GIS Pro. The results identified 931 sq. km area of this landscape needs immediate management interventions where frequent fire incidents and presence of invasive species are high. RCL is well known for its biodiversity wealth and assemblage of various wildlife populations.

Climate-Based Connectivity Analysis of the Loess Plateau with 1km Resolution Based On Pixel-Level Connectivity Indices

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In the context of habitat fragmentation and climate change, maintaining landscape connectivity is critical for the long-term effectiveness of biodiversity conservation. Many indices have been proposed to evaluate connectivity, generally for core patches and ecological networks. In recent years, to evaluate whether landscape can facilitate species' range shifts to track their suitable climate during climate change, scholars have proposed the concept of climate connectivity from the present to the future. The climate connectivity evaluation method provides an idea for high- resolution connectivity evaluation at the pixel level considering climate factors. In this study, we extended the concept of climate connectivity to climate-based connectivity, including three types of connectivity from the present to the present, from the present to the future, and from the future to the future, and proposed a climate-based connectivity evaluation index system at the pixel level. Then, the least cost model (LCP) and circuit theory model were used to evaluate the climate-based connectivity at a resolution of 1km from the present to the present, from the present to the future, and from the future to the future in the Loess Plateau of China, respectively. Finally, we used the systematic conservation planning (SCP) method to identify the priority areas for connectivity protection and improvement. The results showed that the climate-based connectivity evaluation method at the pixel level could effectively guide the long-term planning and practice of connectivity conservation and improvement.

Considering Deer Behavior at Multiple Scales for Restoring Broadleaved Forest

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As the density of ungulates increases in the Northern Hemisphere, damage to planted broadleaf trees by them is increasing. Although the ungulate density is a major factor in determining browsing pressure, it is also known that planting design and site and landscape conditions of planted areas affect the degree of browsing damage. However, the relative importance of these multiple factors and their long-term effects have been unknown. So, we constructed a generalized linear mixed model (GLMM) to explain the survival ratio after 15 years of Japanese oak (*Quercus crispula* Blume) planted in the site damaged by a typhoon in 2004 to reveal the factors affecting deer browsing. We measured and used the following factors; planting design (planted area, and planting density), site condition of planted area (visibility, and the density of

trees on adjacent plantation), and landscape condition of planted area (the distance to roads and rivers, and the areas of canopy gap) in national forests of Hokkaido in Japan. As a result of the model selection by the Akaike information criterion (AIC), it was clear that the oak survival ratio was affected by "Pr (the index of visibility)", "distance to roads", and "planting density". In areas of high deer density, the survival ratio of planted Japanese oaks over a long period was high enough to allow them to grow into the mature stage when they were planted in high density in a site that was in poor visibility and was close to public roads. The results suggest that it is possible to establish mature broadleaved forests even in an area with high ungulates density by applying appropriate planting design and selecting suitable planting sites that considers their behavior in multiple scales.

Distribution and Use of Stone Structures in Three Villages at the Foot of Mt. Hira, Shiga Prefecture, Japan

Wen Wang[1]

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Satoyama landscape are places of human activity in and around villages between pristine nature and the city, where various natural resources are used and managed. Among them, local stones are used as critical natural resources for stone structures such as masonry, lanterns, and Jizo. These stone structures create a unique local landscape and provide a habitat for living creatures, contributing to the biocultural diversity of the region. At the foot of Mt. Hira, the local stone and stone culture is well known, stone processing techniques have been developed for a long time. The stone landscape is unique to the region, and the stone materials and products have been distributed to Kyoto and the areas surrounding Lake Biwa since the Meiji period (1868-1912), taking advantage of the water transportation of Lake Biwa. Even in neighboring villages here, the different topography and geology produced different types of stones and their use patterns. For example, Moriyama village produces Moriyama stone, the only chert in the Mt. Hira, which was transported in large quantities by ship to be used for gardens. Minami-Komatsu produces the finest quality granite, the stone is suitable for stone carvings. Kita-Hira has flourished since the Edo period (1603-1867) as a production center of granite used for shrine gates, building foundations, and stairways. To inherit the unique stone culture, it is necessary to understand the characteristics of stone-related processing techniques, products, and existing conditions. In this study, we targeted Moriyama, Minami-Komatsu, and Kita-Hira villages, and ascertained the distribution, land use, and utilization (type of use, stone type, and size) of stone structures existing in the villages. The objectives were to elucidate the regional characteristic of the stone culture of each village and to identify the connection to the biocultural diversity of the region through the stone resources use and management.

To Walk a Dog or Not? Qualitative Approach to Analyse People–Landscape Relations in Urban Green Spaces

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Urban green spaces (UGS) are, almost by definition, multifunctional landscapes. As a part of urban social-ecological system, they are widely recognized as a major factor affecting health and quality of life in urban environments (WHO, 2016). No doubt exists that these benefits include positive influence on mental and physical health and wellbeing by providing a wide range of opportunities to recreate and relax (Konijnendijk et al., 2013), reduce stress (Ward Thomson et al., 2012), offer opportunities for social interactions and integration, and many other. There are, however, many conflicts and trade-offs among different cultural ecosystem services provided by UGS, and, as a result, among different planning perspectives and land uses of UGS. In this presentation we aim to analyse them using a walking interview method. This method is extremely useful in sustainable and inclusive planning, where practitioners are having to pay increasing attention to how people value and use the spaces in which they live (Evans, Jones 2011). In this way, it can guide landscape ecology towards more people-oriented science. In our research we used it in order to analyse cultural ecosystem services in 5 urban green spaces of Warsaw, Poland, which represent different landscape characteristics. For every area we performed five walking interviews with different stakeholders. This was supported by a qualitative GIS technique. A linkage of (1) in-depth interviews, (2) recording track chosen by respondents, and (3) mapping places where particular attention of the stakeholder was given, helped us to identify and map different conflicts and trade-offs found in each urban green area. The results delivered outcomes which can be supportive for sustainable land use planning and people–landscape relationship in urban environments.

How Temporal Variability in Floral Resources Impact the Stability of Wild Bees Diversity and Watermelon Pollination?

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Temporal variability of resources is a key factor in population and community dynamics. For pollinators, rural landscapes are characterised by flower resource pulse, provided by crops, and more gradual changes in semi-natural habitats contributing to pollinators persistence and population stability. In this study, we hypothesized that organically managed watermelon fields surrounded by landscapes with semi-natural habitats and high level and stable flower resources host abundant and diverse wild bee communities and provide a high and stable pollination of the crop. We studied wild bee communities in 63 watermelon fields (California) and their surrounding at three dates during the watermelon flowering period. Based on the inter-tegular distance of the actually recorded wild bee species, we investigated two buffer sizes: 190 m and 330

m radius. Organic management and small size of watermelon fields had strong and positive influence on richness and abundance of wild bees. The two buffer sizes exhibited similar results, underlying the importance of the close surrounding of the field. The proportion of the land cover offering floral resources and the variability of these resources were negatively linked to wild bee abundance and its temporal stability. High minimum flower abundance (in March) was linked to more functionally diverse bee communities and was the only variable contributing to the stability of watermelon pollination. Our study also pointed out the positive effect of the proportion of SNH in the landscape on wild bee abundance and functional dispersion but a negative effect of the diversity of SNH on bee abundance and pollination stability. Our results suggest that providing flowering resources at the very beginning of the growing season and maintaining a high proportion of SNH around small and organic crops would increase bee abundance, diversity and stability as well as the stability of watermelon pollination provided by wild bees.

Exploring the Relationships between Local Participation and Perceived Co-management Performances: Evidence from China's National Park

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Understanding local perceptions is essential to secure the proper functioning of co-management in protected areas. However, scientific investigations have virtually ignored the quantitative assessment of the extent to which shall locals be empowered to ensure optimistic judgements towards co-management. Against this background, this paper seeks to investigate the effects of varied participation types and levels on perceived performances in a centralized co-management regime in Giant Panda National Park, China. Using 17 semi-structured interviews and 353 survey questionnaires, our research identified six co-management subtypes, classifying into four empowering levels: instructive, consultative, agreement and cooperative degrees. Surprisingly, the multivariable analysis points to a very sobering fact that the involvement in the equally cooperative level (type) is not significantly linked with more favorable perceptions. In contrast, local residents engaged in the lowest instructive level of co-management (supportive, training, and employment subtypes) are inclined to develop positive attitudes across ecological, social and livelihood dimensions. This study has come up with a succinct conclusion that merely empowering locals might not facilitate perceived successes among local dwellers, and the enforcement of instructive co-management intending to enhance local well-being is commendable, particularly in a top-down co-management regime. In addition, this paper advocate for more attention to increasing the livelihood impact of co-management policies, especially for the low-income, elder, and less educated groups residing around China's national parks.

Bats and their Role in Agricultural Landscapes: Zambia as a Case Study

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Human population growth is increasing pressure on our natural resources and habitats. Crop production in particular results in large scale land clearance and is known to be one of the largest drivers of habitat loss; however, these landscapes can also result in conditions favourable to particular species assemblages. The study of species assemblages can tell us about the potential effects of anthropogenic activity on ecosystem functions. Bats can be used as indicators in this regard, with a wide diversity of species co-existing in a variety or niches, with different levels of resilience to human disturbance. Studies worldwide provided evidence for a provision of ecosystem services insectivorous bats, with some demonstrating that they can reduce insect pest populations significantly. For Africa, insect pest control services by bats and the effects of agriculture on biodiversity have been largely understudied. Our research focuses on how bats use agricultural landscapes so as to better understand effects of agriculture on bat diversity and ecology, but also investigate the potential provision of insect pest control services by bats in an Afrotropic environment. Acoustic and trapping methods were used to record bat species assemblages and activity levels on 30 farms in Zambia during cropping seasons. The possible effects of crop and larger variables were investigated. Insect traps were used to assess food availability and droppings were collected for dietary analysis by molecular techniques to screen for known crop pests in diets. Initial findings will be presented with activity of some species guilds over cropped areas in the farming landscape and crop pests were found in the diet of these species. This indicates a contribution to insect pest suppression or control in these landscapes and a need to monitor these species in both natural and anthropogenic ecosystems.

CO-DEVELOPMENT OF URBAN NBS IN THE GLOBAL SOUTH: CHALLENGES, STRATEGIES AND CASES

Co-Producing Greener Urban Schools in Latin America

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This presentation is based on an action research project co-produced with several school communities in the metropolitan area of Buenos Aires. The city is the national capital and centre of the wealthiest region of Argentina -- a middle income country, which nevertheless faces multiple economic, social and environmental development challenges. Amidst these, we argue that the lack of green space per capita and an urban environment that is not conducive to health and well-being could be mitigated through nature-based solutions that take urban vegetation more seriously as an urban infrastructure. The presentation will explain how we identified urban schools as opportunity areas for installing site-specific, multi-purpose formats of green infrastructure and to strengthen the city's green spaces network and the work we are doing with pilot schools. We will reflect on the multiple barriers that we encountered for co-producing NBS and potential strategies to overcome them. The presentation will conclude with a reflection on how schools be mobilised for the promotion of urban NBS beyond Buenos Aires.

Improving guidance on NBS co-development in the global South

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Nature-based solutions (NBS) are promoted as a means for positive transformation of cities into healthy, climate-resilient and biodiverse living environments. To support the uptake of NBS in practice, guidance material, such as handbooks, toolboxes and manuals are developed. However, many of these materials result from European projects and case studies, which might not meet the needs to address the complex socio-political situation of many cities in the Global South. Yet, specifically due to the existing socio-economic inequalities and weak governance structures, support and guidance to implement NBS collaboratively for a just and inclusive transformation are called for. We question whether current guidance materials provide enough support for local actors in the Global South, and more importantly ask how practitioners can be better aided. To understand the needs of local actors for NBS guidance, we conducted semi-structured interviews with questions on the availability and usability of NBS guidance as well as on potentials for improvement. The interviews were conducted in the period March 2021 – December 2022 with 21 actors from four case studies in Latin America: Bogota (CO), Buenos Aires (AR), Santiago

(CL), and Sao Paolo (BR). As NBS guidance often can aim at different target groups, we interviewed for each case city 2-4 actors representing different organisational backgrounds, e.g., governmental, private sector, NGO. Notwithstanding their background, these persons were selected based on their involvement and experience in the planning, governance and management of open spaces. The interviews were recorded, transcribed and if needed translated to English. The transcribed interviews were analysed through a qualitative content analysis with the aid of MAXQDA software. Based on the interviews, we present current use and experiences with NBS guidance material of local actors in four Latin American cities. Next to the positive features of current material, we describe the shortcomings these actors perceive regarding content and information. Finally, we provide suggestions regarding content and format on how guidance can be improved to meet the needs of actors in the Global South.

The Many Barriers to The Widespread Uptake of Nature-Based Solutions in Rapidly Expanding Cities

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The majority of future urban expansion will occur in low-income regions, with Africa urbanising faster than any other continent. While cities are centres of economic development, challenges exist in how to manage their growth to ensure human wellbeing is prioritised. One key measure which is recognised as essential in urban sustainability is the provision of high quality, accessible natural environments. Nevertheless, as cities expand, the retention, rehabilitation and restoration of urban greenspaces, the implementation of urban green infrastructure networks and the application of nature-based solutions (NbS) remain low priorities and/or are poorly implemented in urban planning and development processes. This is despite the plethora of evidence that demonstrates the important role that high quality, well-functioning ecosystems play in climate change mitigation, providing habitat for biodiversity and supporting the delivery of multiple ecosystem services for all urban residents.Drawing on work from Ghana and Malawi that used a mix of participatory approaches, interviews, focus groups and policy analysis, we explore how the challenges, benefits and purposes of NbS are viewed across multiple stakeholder groups, including residents, decision-makers, public and traditional authorities, private and third sector organisations. Key findings were that there is: (i) considerable variation in how NbS are perceived across stakeholder groups, (ii) a lack of support for urban greenspace retention and provision among stakeholders with the greatest influence on land-use decision making, and (iii) minimal coherence and mainstreaming of urban green infrastructure concepts into policy. Combined, such findings present substantial barriers for the widespread uptake of NbS. Nevertheless, many participants in our studies were supportive of the importance of natural environments within cities. Building on this support to co-develop locally appropriate mechanisms to help ensure that the full value of NbS is understood, and subsequently incorporated into decision-making processes, could help unlock the potential of NbS to address multiple environmental challenges, and deliver greater and more

equitable wellbeing gains to those living in rapidly-expanding cities.

Beyond Experimentation: Are Urban NBS Living Labs in Europe and Latin America Designed for Transformative Change?

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Amid the world's growing socio-environmental challenges such as climate change, land and biodiversity degradation, and rapid urbanization, Nature-based Solutions (NbS) have emerged as a potential multifunctional global response. Although the use of NbS has been slowly increasing, their incorporation into city planning and development still needs to be accelerated. Despite NbS co-benefits for urban environments as air, soil, biodiversity, and water quality improvements, and other socio-economic benefits, NbS continue to struggle to compete with conventional development approaches that dominate urban landscapes, and the prevailing urban governance regimes. Living Labs (LL), open innovation ecosystems experiments in real-life environments, have been widely promoted as a stepping stone to initiate transformation of the socio-technical systems in place and foster urban NBS uptake. However, there is limited knowledge regarding their contribution to transformative change. Living Labs are often reported to be isolated small projects, and to not always hold intentions questioning their capability to generate meaningful impact beyond their boundaries. There is a need to better understand how such co-production projects can support NbS adoption in urban environments and foster social-technical transitions, in particular in regions where the concept of Living Lab is less developed, such as Latin America (LA). In Europe rich experience with urban Living Labs has been developed through multiple EU funded projects. However, knowledge exchange between LA and EU on urban NbS Living Labs co-production still is at its beginning. Therefore, this study analyzes Living Labs' early actions to explore their potential to contribute to transformative change, within two distinct contexts, EU and LA. Drawing on four urban Living Labs in Barcelona, Buenos Aires, Santiago, and Turin, part of the H2020 project CONEXUS " urban nature connects us", this study aims to (i) identify what type of actions NbS Living Labs in urban environments are developing in EU and LA; (ii) understand what are the intentions and motivations behind their design and planning and how they are related to transformative change; and (iii) investigate how Living Labs activities can impact NBS adoption in and beyond their boundaries within the two regions. A mixed methods approach is applied consisting of the review of Living Labs' documents to take stock of the LLs activities and objectives formally reported; semi-structured qualitative interviews to gather insights LLs design process and participants' perspectives; and a literature review to assess LL successful impact factors and failure risks towards transformative change. The results of this paper are expected to support municipalities and other organizations from different backgrounds to more

effectively and easily prioritize and plan Living Lab actions and co- production activities as mechanisms of change when replicating or scaling up those projects. This research will further allow a reflection on the role of Living Labs in the adoption of NbS and bring evidence from Latin American contexts, contributing to closing the informational gap present in the region.

Urban Ecosystem Services Supply and Demand Co-Assessment for Urban Green Infrastructure Planning in Three Cities of Ethiopia

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Ethiopia is in a state of rapid urbanization, growing annually with 3.8%, with an expectation of the urban population to increase from 26.6 million in 2021 to 42.3 million in 2037. The urban growth is largely characterized by urban sprawl resulting in the conversion of productive farm lands and vegetated areas into built up area and engulfing peri-urban areas. This has resulted in various environmental problems affecting environmental quality, people's livelihood as well as social cohesion. Urban green infrastructure (UGI) has been recognized as a potent tool for bringing sustainable development across the world. UGI planning need to consider the current supply and current and future demand of ecosystem services by UGI. The identification of UGI in the three cities was done through a mapping of the current UGI based on remote sensed data and ground truthing. The UGI was categorized using appropriate typology. To understand the current provision and current and future demand of ecosystem services by the UGI, co-assessment with experts drawn from different offices of the three municipalities was employed. Fourteen land use types were identified for the city of Addis Ababa with perennial vegetation and urban agriculture constituting 11.5% and 23.4% of the city's land area respectively. For Adama city, agriculture and perennial vegetation constitute 38.8% and 16.3% respectively. In Kombolcha city, agriculture is the dominant land use covering 51% of the city's land area, and perennial vegetation constitutes 17.8%. In the three cities, the provision of regulating services in particular, flood Control, air quality regulation, water quality regulation, erosion prevention and local climate regulation emerged as an important future priority with current provision at an intermediate or low level. Therefore, future urban planning/urban green space planning needs to consider the identification, development and management of urban green spaces that could provide the prioritized regulatory ecosystem services.

NBS for the Urban-Rural Transition Areas: Hydro-Social Territories in the City of Bogotá

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Latin American cities are characterised by a strong phenomenon of informal growth, which generally occurs in the urban borders. In these areas, a series of conditions often result in critical barriers for organized urban expansion processes, becoming challenges for governments and inhabitants and often resulting in social and spatial segregation. Bogotá, the capital of Colombia, is one of the cities that has received the largest number of migrant populations from different parts of the country, with rural or ethnic roots, and diverse ways of relating to nature. Although such phenomenon poses a number of challenges for biodiversity management it also offers opportunities, particularly for the co-creation of nature-based solutions related to green public space generation, ecosystem restoration, and nature-based or agro-based tourism implementations. We will present preliminary results and lessons learnt of the Bogotá Life-Lab from CONEXUS project, in which we address urban-rural transition zone challenges on two areas in the northern and southern borders of Bogotá, which have been heavily affected by urban expansion processes. Through participatory planning and co-creation, this life-Lab is working on hydro-social systems integrating the socio-ecological approach and the multiple benefits offered by SBNs.

Science-Design Loops for the Design of Blue-Green Resilient Urban Landscapes: A Case Study in Antananarivo, Madagascar

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Urban landscapes face significant challenges in their transformation towards sustainability while maintaining resilience. Landscape designers are tasked with creating new solutions that can deliver and maintain key ecosystem services over time, especially in the aftermath of shocks. This is a complex task that requires intense dialogue with scientists, engineers, and stakeholders who can provide expertise on ecosystem functions and services. First, we introduce a roadmap for the design of blue-green infrastructures that centers on an intensive transdisciplinary dialogue - a science-design loop. This roadmap is based on lessons learned from five key projects worldwide related to flood management and blue-green landscape design. By engaging in a science-design feedback loop, designers are challenged by scientists' models and simulations, as well as stakeholders, enabling them to create informed designs that better address the complex challenges of urban landscapes. We illustrate this roadmap through a case study in Antananarivo, Madagascar, where the design focuses on creating blue-green infrastructure to enhance flood resilience and ecosystem service delivery. In this case, we use point cloud models of the city as a boundary object between scientists, landscape designers, and stakeholders. We utilize these models to test flood

simulations, integrate ecosystem services data, and employ a visualization tool to engage stakeholders in providing constructive criticism to tune the design to their needs. This results in a high-quality landscape design proposal that balances the solution-driven approach of designers, the problem-solving skills of scientists, and the guardrails of the final users. Overall, our research underscores the relevance of a science-design loop in creating balanced and informed designs for blue- green resilient urban landscapes.

Human-Nature Relationships and Social Equity as Factors of Sustainable Ecological Resource Management in Marginalised Communities

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Urban ecological resources, including local community parks are vital for urban sustainability, resilience and community well-being. However, such resources are also often overlooked in urban planning strategies, especially in countries grappling with myriad socio-economic and political challenges. Often, social housing and grey infrastructure trump the consideration of urban ecological resources and green infrastructure. The result is that parks and other open space resources are degraded, and often unmaintained. In this paper, the City of Tshwane in South Africa, is considered through the dual lenses of geovisualisation and qualitative, ethnographical research to identify environmental and social justice factors and unique human-nature relationships that do, and/or should factor into landscape and ecological planning. The study found that communities on the urban peripheries of the CoT are at increased risk of experiencing socio-economic and spatial inequities related to urban ecological resources. This has implications for the sustainability of the resources on the urban peripheries of the city; based on the increased pressure on natural resources. However, the study also found that at the local scale there are human-nature relationships that suggest potential for regenerative practice through community stewardship and co-development strategies. The study concludes that both macro-scale mapping, and local community perspectives should be considered in the planning and management of urban ecological resources, to enhance grass- roots initiatives. Additionally, policy-makers, government officials and practitioners need to be cognizant that unique contexts need unique approaches, which are ideally arrived at by the dual consideration of the urban, and local scales. Preferred themes: Ecological sustainability in urban landscapes and smart cities; Drivers of landscape change and sustainability at multiple scales

Key words: environmental justice, community parks, urban ecological resources, City of Tshwane, urban planning, landscape architecture

Implementation of Natured-based Solutions in planning and design of small and medium-sized cities in South Africa

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Nature-based solutions (NBS) continuously attract attention globally in the planning, design, and management of sustainable and resilient cities. The implementation of NBS is challenged in the Global South by rampant urbanization and sprawl, land invasion and ecological degradation, ineffective policy and legislation, a lack of ecological planning initiatives, competing interests and vulnerability to climate change and natural disasters. Sub-Saharan Africa has witnessed exponential growth in studies on NBS, with scholarship focusing on integrated approaches to address water and food security, human health, climate change, and disaster risks. South Africa has been especially well represented in the contemporary literature, but efforts have mostly neglected case studies in small- and medium sized cities where major future urbanisation will occur. These localities differ significantly from larger, better-resourced cities in terms of social, economic, and ecological characteristics, offering specific challenges and opportunities for the adoption of NBS. This presentation investigates South African case studies related to the implementation of NBS in various forms in small- and medium sized cities, focusing on aspects like representation, stakeholder engagement, collaboration and transdisciplinary in the initiation, planning, development, and maintenance of NBS. Specific challenges are recognised, including facilitating multi-stakeholder engagement and buy-in, nurturing community involvement, and knowledge gaps in professional expertise. Challenges are exacerbated by the limited capacity of most smaller local governments to pursue alternative approaches or meet demanding normative ideals on participation. Yet, case studies offer important insights on the involvement of varied stakeholders, including historically disadvantaged groups in decision-making processes to transcend tokenistic forms of participation and advance the co-design, co-implementation and co-management of NBS at project, neighbourhood and city level. Lessons vary from the development of multi-functional green spaces that incorporate child-friendly or place-making principles to the implementation of citizen-led greening strategies in urban agriculture that promote bottom-up processes empowered by learning-by-doing.

Pathways to Water Resilience? Exploring the Narratives Framing Nature-Based Solutions Climate Action Pathways in Cape Town and Johannesburg

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Experimentation with Nature-based Solutions (NbS) has emerged as a well-documented avenue of climate action for transformative urban futures. In this article, we seek to give view into the different narratives underpinning nascent NbS climate action pathways in the Global South cities of Cape Town and Johannesburg. We explore examples of city-directed experimentation, community-level scientific demonstration, private sector-led NbS initiatives as well as others. We find that

while both cities exhibit vibrant NbS-supportive policy mixes, implementation of NbS in pursuit of water resilience lacks sustained momentum and remains difficult to amplify. Each alternative pathway towards water resilience through NbS is underpinned and framed by different narratives and values, each subject to contestation, whilst other imagined pathways such as NbS in informal areas remain difficult to resolve and therefore unseen. With these findings, we consider whether/where opportunities for disruptive and enabling decolonial transformations through diverse pathways of NbS may be found in post-colonial cities.

Urban Resilience in Flood Prone Neighbourhoods of North Central, Nigeria

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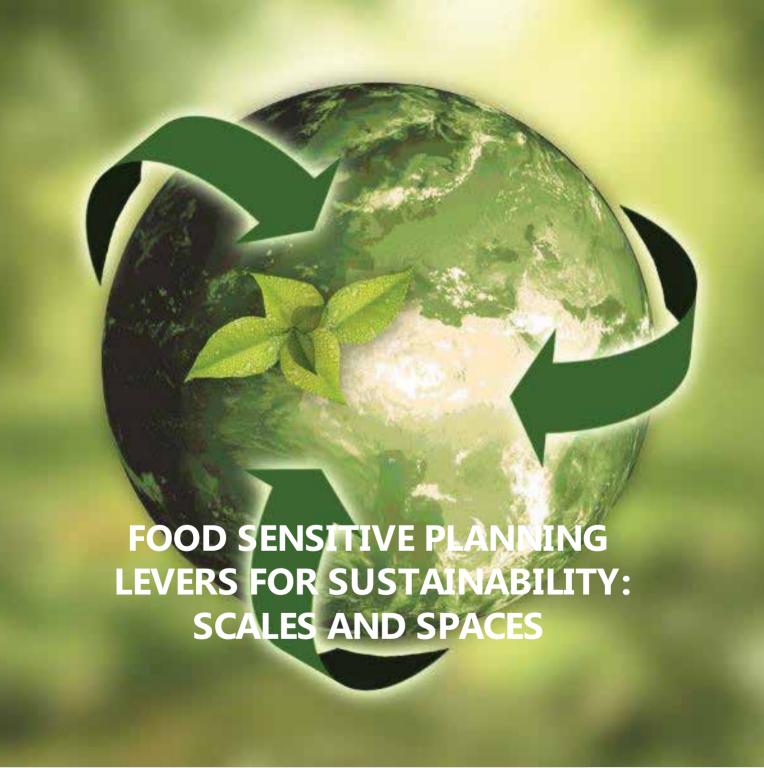
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Nigerian cities are ravaged by the negative impact of climate change. The effects of climate change result from climatic anomalies such as heat waves, water shortage and stress, drought and flooding. In North-

Central cities of Nigeria, floods remain a threat to community's sustainability. This study assesses flood resilience in the north-central cities of Nigeria. The specific objective of this study was to examine the resilience efforts to flooding in cities of North-Central Nigeria. This was done through the systematic review of literature on flood and urban resilience in the study region. The study reveals that uncoordinated urban planning, lack of political will to follow through infrastructural development planning in the cities understudy threatens urban resilience to flooding. Thus, recommends an inclusive planning approach that strengthens communities' capacity and ability to flooding management.

Keywords: Climate Change, Cities, Flood, Nigeria and Resilience

FOOD SENSITIVE PLANNING LEVERS FOR SUSTAINABILITY: SCALES AND SPACES

Modelling Approaches for Participatory Food Governance in City-Regions

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As centres of consumption, knowledge and services under some political and administrative control, cities are acknowledged as strategic food governance transition nodes. Increasing stakeholder coordination and participation, however, means identifying pathways for transformative change and accelerating uptake of innovative and participatory modes of governance. We argue that modelling approaches, by helping to meet the three pre-conditions for participatory governance (relationship-building, shared understanding and experimentation) offer valuable input and can help establish ad hoc institutional space for redesigning food system governance. Based on a selective literature review, we define four key dimensions to consider when modelling for participatory food governance in city-regions: stakeholders' involvement, process phases, capacity for joint action and use of a multi-sectoral and multi-scale approach. The state-of-the-art review presented in this paper focuses on seven modelling approaches that can meaningfully support stakeholder participation in food system transitioning processes, considering the specific context, objectives and available resources. The strengths and limitations of (combined) modelling approaches are illustrated and critically reviewed. This highlights the relevant contribution that modelling can make to creating new spaces for participatory food governance.

Key words: regionalisation of food policy; food governance; transition; joint action; transdisciplinarity

Exploring Climate-Resilient Livelihoods: Edible Living Walls with Traditional African Vegetables

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A paradigm shift is necessary to reconfigure global and Sub-Saharan African (SSA) agricultural practices and food systems in response to growing planetary concerns. These concerns include poverty, food security, decent work and economic growth, sustainable cities, climate change and biodiversity. In South Africa, the growing population, rapid urbanisation, poverty, and unemployment exacerbate the issue of food security (SDG2), even more so considering climate change (SDG 13). As significant carbon emission contributors, agriculture and cities, which include road transport, industries, and buildings, must respond to global issues and integrate green initiatives to create climate-resilient livelihoods and food security. This experimental study aims to analyse the efficiency of outdoor modular living wall systems (LWSs) with traditional African vegetables (TAV) to create household food security. A quantitative methodology was employed to measure ecologically and statistically analyse and compare the efficiency of locally produced selected LWSs and TAV for vertical food production in

Gauteng. This study monitored TAV crops over six months. Variables included minimum and maximum daily temperatures, relative humidity, precipitation, soil temperature, water content and electrical conductivity, plant stress and leaf biomass yield. In urban areas, LWSs in interstitial spaces can produce a higher yield per horizontal footprint than traditional soil- based food production to improve household food security. LWSs must be optimised to create optimal habitat conditions by using local materials, orientation for ample sun exposure, sufficient size soil volume in the pots, irrigation to ensure adequate available water, and drainage. Six TAV crops showed potential for urban food production in modular LWSs withstanding high peak temperatures and dry periods. Edible LWSs with TAV could effectively create climate-resilient livelihoods with household food security.

Keywords: climate-resilient livelihoods, household food security, traditional African vegetables, modular living wall systems, resilient urban food production

Developing Collaborative, Multisectoral, Socio-Ecological Interventions to Address the Numerous Dimensions of Malnutrition in Western Rwanda

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Rwanda's Western Province, along Lake Kivu and neighboring the Democratic Republic of Congo (DRC), is seen as Rwanda's food basket thanks to its fertile, volcanic soils. However, the <5 stunting prevalence (40% as per DHS 2019-20) is substantially higher in the Western Province compared to other provinces. Similarly, only <10% of interviewed farmers in the foodsheds of Rubavu and Rusizi have good knowledge about diversified diets and 2/3 of surveyed women have inadequately diverse diets based on the Minimum Dietary Diversity for Women (MDD-W) indicator. The Nutrition in City Ecosystems (NICE) project promotes local, well-balanced, quality nutrition through available, accessible and affordable food items for urban populations in Rubavu and Rusizi through participative, interdisciplinary agricultural, food, and health sector collaborations. Based on government buy-in, nutrition-improvement potential, production feasibility, market potential, income generation, agroecology potential, and consumers buy-in, value chains have been selected in a multisectoral, multi-stakeholder approach. Infrastructural and agroecological interventions such as the farmers' hub social business model and soil erosion measures through agroforestry are currently implemented, along with demand generation activities to raise awareness for diversified diets and agroecological practices. Multisectoral food systems sub-committees, meeting quarterly and aiming to strengthen coordination and planning among the different sectors, have been established. City food systems activity plans and corresponding monitoring and evaluation systems are currently implemented by the food systems platforms together with activities to further disseminate the food systems thinking into the different sectors.The (double) burden of malnutrition in Rubavu and Rusizi cities, areas with high agricultural production but also high cross-border business activities that drain produce to neighboring DRC, can only be tackled through participative planning, mutual, intersectoral understanding and advocacy, and institutional and organized proximity between all stakeholders.

Typologies of Rural Vulnerability in Spain

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Worldwide, rising concerns about pre-existing threats to food security and livelihoods have influenced the political and scientific debate regarding the vulnerability of rural landscapes as a social-ecological system. In this study, we identified spatially and statistically the main typologies of rural vulnerability to climate change, depopulation and globalization of agricultural markets in rural Spain. We acquired the data from different sources that measure three stressors (climate change, depopulation and globalization) and components (sensitivity, exposure and adaptive capacity) at the municipal level. We performed principal components analysis followed by hierarchical cluster analysis. Cluster 1 ("depopulation and globalization" cluster) grouped the most vulnerable municipalities to depopulation, as it presented the highest decrease in population growth, the highest number of aged and young people, the lowest connectivity to rural areas, the highest proportion of small centers and low adaptive capacity in terms of percentage of social infrastructures. Further, cluster 1 has the highest average in economic loss, associated with a high dependence on agricultural activities that are vulnerable to competition from imported food products. Cluster 2 ("depopulation and climate change" cluster), is characterized by the highest decrease in rainfall rates and the highest dependence on agricultural activities that are very sensitive to rainfall. Municipalities in this cluster were sensible and exposed to depopulation as well. Municipalities grouped into cluster 3 are the most sparsely distributed; they are distinctively exposed to temperature increases and sensitive to wildfire increases and soil erosion, which makes them highly vulnerable to climate change. Cluster 4 grouped municipalities located near the coast and presented a high dependence on agricultural export activities. The mapped typologies of vulnerabilities can support rural development and landscape planning as they provide the spatial characterization of the interaction of several threats and strengths in rural landscapes as a social-ecological system.

Keywords: cluster analysis; multidimensional; rural development; rural vulnerability; socio- ecological system.

Innovative and Adaptive Urban and Peri-Urban Agriculture: A Tool of Building Resilience and Enhancing Food Security in Kenya

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Urban agriculture is likely to become a major contributor to food security for urban residents in third world countries, who are projected to comprise more than half of the world population by 2050. Food production within urban homesteads and community gardens provide several potential benefits including; building economical resilience, enhancing nutrition, reducing ecological footprints, and improving environmental habitability. In order for urban agriculture to be sustainable, several food production challenges must be addressed including; limited farming space, novel climatic conditions associated with urban heat island effect, handling solid waste, water insecurity, waterborne diseases, air and water pollution. Through a systematic literature review and observation method, we explore the various innovative and adaptive farming techniques used by urban and peri-urban farmers in Kenya and discuss the potential economic, social and environmental benefits of urban agriculture in the country.

Keywords: Urban agriculture, Food insecurity, Community gardens, Sustainable

Food As Commons: Fostering Community Food Sovereignty in Neighbourhoods through Participatory Urban Agriculture, The Case of Terrazas Productivas in CSCSM in Quito

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Community structures are evident around Quito and foster neighbourhood management, social solidarity and safeguarding of the commons. The case of Terrazas Productivas, a rooftop urban agriculture initiative aiming to enhance social solidarity and food security in a social neighbourhood in Quito, employing a communitary, participative, educational and productive approach, promotes self-sufficiency, neighbourhood cooperation, knowledge interchange and food security and sovereignty. Based on a distinct notion of territory and property, working with the community to enhance social resilience and climate mitigation, using tools and networks offered by academic institutions, Terrazas Productivas plants the seeds towards a locally based, resilient model of food sovereignty, fostering sustainable local development, creating new urban narratives and rearticulating the urban-rural divide of food produce.

Current Governance of the Olive Oil Sector in Alentejo (Portugal) is Schizophrenic: Implications (and Opportunities) at Landscape and Territorial Scales

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Alentejo (Portugal) is currently ongoing a rapid process of transformation of the agricultural farming systems that are the functional core of its rural landscapes. Change is driven by global complex processes including agricultural financialization, intensification and de-territorialization. These processes are facilitated by a shift in the availability of natural resources, namely water for irrigation, and by strong political, financial and social support. The impact of such processes is most apparent in the olive oil sector, which is presented alternatively as a model of success for agricultural intensification, or as a deterrent of sustainability for rural landscapes shaped by traditional farming systems. However, scientific evidence is clear that multiple management models co-exist with different impacts on sustainability, largely neglecting the intensive-extensive dichotomy, which is therefore rendered as an inaccurate proxy for sustainability. Driving current changes, a governance framework exists that is reflective of the schizophrenic dynamic in which the olive sector is subsumed and presents poor levels of (internal and external) coherence, coordination, and cooperation. In this paper we will map the current governance framework and describe the main limitations and opportunities for improvement. The main one being the need to expand the current focus on the farm (operational) scale and on upscaling for strategic and political purposes, towards multi-level governance options that are better reflective of the heterogeneity and complexity in this sector and landscapes. To achieve this, the re-territorialization of the sector is necessary, a goal for which innovative landscape approaches might prove useful. These approaches are aimed at reconciling food production, biodiversity conservation and other multiple ES across multiple scales. An examination of the principles and conditions for implementation of Landscape Approach(es) in the olive farming systems of Alentejo will be discussed that are ultimately aimed at restoring (governance) sanity and achieving sustainability standards that are SMART.

The Role of Fisheries Cooperatives in Adaptation with Climate Change and Fostering Sustainable Development

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Changing climate will have a considerable impact on nature and valuable services provided by ecosystem to the society. As an important ecosystem service, global small-scale fisheries sector plays a pivotal role in food security and provides livelihoods of millions of people. The small-scale fisheries are typically operated by small groups of fishers which also support other industries such as boat building, gear making, and fish processing and marketing. However, small-scale fisheries are facing a number of challenges especially due to climate change, overfishing and user's conflicts. Fisheries co-management is one of the good measures to manage a fisheries resource by directly involving fishermen in the management system. However, still there is an ongoing discussion whether fisheries co-management practices can achieve sustainability under the climate uncertainty, especially in case of transboundary fish stocks where

multiple stakeholders are involved in traditional management system. Therefore, the present study takes a sustainability approach to examine whether fisheries cooperatives can foster sustainable management of small-scale fisheries resources. To achieve this goal, this paper analyses the efficacy of community-based fisheries cooperatives of three Asian countries through the lens of the UN's sustainable development goals.

To What Extent Does the Agri-Food Supply Chain of Fruits and Vegetables Contribute to the Reterritorialization of Agriculture in the City of Meknes?

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The COVID-19 pandemic challenged the fruit and vegetable supply chain, forcing prefectures in Morocco to close down or partially close down certain channels through which fruit and vegetables were distributed, such as local markets and restaurants. Fear of contamination, social distancing measures and time and distance limitations also made it difficult to sell fruit and vegetables. This meant that alternative ways of exchanging produce between consumers and sellers had to be found. The study that we conducted in the cities of Errachidia and Meknes clearly shows a changé in consumer purchasing practices for vegetables and fruit. Indeed, we are currently observing, in parallel with the pandemic, a return to local products after the closure of certain borders, the development of short supply circuits through online purchasing or local purchasing in response to the sanitary restrictions in place (limited travel). Thus, short and direct circuits seem to be the most adapted to this new sanitary and institutional environment. Three types of distribution channels have thus rapidly emerged, namely: Street vending with a three-wheeler, carts or traditional trolleys; Buying from local traders or local fruit and vegetable shops; Purchasing via electronic platforms. The question then arises : do these forms of distribution contribute to the reterritorialization of sustainable agriculture in the city of Meknes ? The methodology developed in this paper is based essentially on the mobilisation of two approaches. The first is qualitative, in order to understand the organisation of the different interactions of the actors in the agri-food supply chain of fruit and vegetables, and the second is quantitative, via a field survey.

An Exploratory Analysis of the Relations Between Land Systems and Small Farm Distribution in Mediterranean Europe

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The Mediterranean area is ongoing strong changes particularly related to agricultural land uses. At the same time, this region is characterized by a traditional heterogenous landscape mosaic, where small farms are predominant. Previous analysis identified the distribution and the role of small farms in Europe and the ongoing dynamics occurring on the Mediterranean area. Using this information, we aimed to explore if Mediterranean small farms are predominantly localized in some specific land systems and if they are particularly affected by some specific dynamics. In particular, we performed a spatial analysis overlapping four different geodatabases obtained from two international projects concluded on the recent years (Horizon2020-SALSA 2016-2020 and Arimnet2-DIVERCROP 2017-2021). These databases represent: 1) the land system distribution and 2) the land system dynamics (between 2005 and 2015) on the Mediterranean area; 3) a classification of the NUTS3 European regions based on the presence of small farms and 4) a series of buffers (10, 20 and 30 km) around a sample of small farms. The analysis was developed on the Mediterranean European region. The first results obtained showed that: i) the NUTS3 regions where there is a predominance of small farms are mainly characterized by the presence of intensive arboriculture, alternated with other irrigated crops, in particular vegetables and oil crops; ii) as expected periurbanization is the main dynamic occurring on small farms NUTS3 regions, but intensification and specialization are also widespread, significantly more than in the general distribution. In terms of the buffer around the small farms sample, peasant farms and the new small enterprises are mainly located on intensive plain while intensification is the most common dynamic, mainly around diversified businesses small farm type. These results can improve the understanding regarding the whereabouts of small farms in Mediterranean land systems and the planning of small-farms based food systems.

Analysis of the Consequences of Climate Uncertainties on High Altitude Agro-Pastoral Socio- Ecosystems (France): Interdisciplinary Approach of the 2022 Alpine Drought on Ovine Production

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The dynamics of high-altitude socio-ecosystems are jointly dependent on human practices and climate change. While high-altitude environments are already undergoing significant biophysical transformations, both the magnitude and direction of forthcoming changes are subject to large uncertainties in the current climate models. Previous studies have also shown that predicting the effects of forthcoming climate change is less important in farmers' choices for maintaining their pastoral activities than being able to cope with inter-annual climatic variations and uncertain weather events. In this context, both placing uncertainty at the center of pastoral adaptation practices and using ecological indicators is of foremost importance to understand the dynamics of montainous socio-ecosystems. We will present here ongoing research (ANR/TOP scientific programme) aiming at combining a range of measurable quantitative indicators on landscape ecology and climate science with qualitative data derived from semi-directive interviews with a range of agro-pastoralism actors (breeders, shepherds, collectives and formal institutions). The aim is to build an innovative analysis method for monitoring practices evolution. Premilinary results reveal that drought episodes do not necessarily lead to substancial immediate practices modifications. For instance, during summer 2022 drought in the French Alps, most flocks did not leave the mountain earlier than usual, partly due to late-season rainfalls mitigating the drought's negative impact on herbaceous resources availability. However, *posteriori adaptations* were choosen, including unexpected purchase of extra hay or delay in lamb slaughter period, or dealt with, namely lower than usual meat quantity and quality. Beyond a mere improvement in the understanding of complex high-altitude socio-ecosystems, our presentation aims at highlighting the importance of a holistic methodology interlinking impacts of climatic variations and ecological processes for studying pastoral practices adaptations.

City and Agriculture - Is there a Correlation with the Complexity of the Shape of City and Agricultural Production to Local Markets ?

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The objective of this presentation is based on research in quantitative geography, shedding light on the analysis of the relationship between city and agriculture

with respect to the issue of local supply, in order to help public arbitration. In this research, we hypothesize that the more complex the urban boundaries are (roughness, rugosity), the more positive the effect on the orientation of local production towards local markets. Firstly, on the urban side, we will explain the methodology used in spatial analysis to calculate the rugosity (Brinkley, 2018) of the urban boundary, based on a few cities in southern France. Secondly, on the agricultural side, we will present a methodology in spatial analysis to detect the spatial signature preferably oriented local agriculture (Sanz Sanz, 2016, Deffontaines,1997). In conclusion, we will confront these two parts and verify by simple statistics, if there is a sign between the rugosity of the urban boundary with the agricultural signature with local tendency. The results will be presented in graphical and map form, with the aim of animating and sharing interesting information for a wide range of participants at the Iale World congres in 2023.

A Framework to Identify Conservation Priority Areas for "30x30" Target While Ensuring Food Security in a Cost-Effective Way

Rui Yang[1]

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There is a growing consensus that expanding biodiversity conservation actions beyond protected areas is necessary. However, it remains unclear where and how to expand conservation efforts while balancing crop-related food security challenges. To address this, we developed a framework that identifies cost-effective areas for expanding protected areas and other effective area-based conservation measures (OECMs), and applied it to China. By combining templates for global biodiversity conservation priorities and the priority conservation areas with lowest simulated extinction risk based on 2,413 vertebrates' habitats in China, we identified the areas with high biodiversity conservation value. We then categorized the priority areas into four types based on their degree of human influence, indicating the potential cost of management. By considering both conservation value and management cost, we identified the most cost-effective areas for expanding protected areas and OECMs in China while excluding current and predicted cropland for food security in two scenarios. The results indicate that China could expand protected areas to 22.81% of its land area in conservation priority areas with low human impact, and establish OECMs in areas accounting for 8.73% and 16.67% of the country's land area in a cost-effective approach in two scenarios. In the ambitious scenario, protected and conserved areas could cover up to 40.18% of terrestrial area, partially or completely covering the habitat of 2,392 (99.13%) species with an average coverage of 44.65%. This framework could be applied by countries to identify their protected areas and OECM expansion priorities and achieve post-2020 biodiversity conservation goals.

Learning From the South: Discovering the Benefits and Estimating the Impacts of Urban Agriculture in

Bogotá (Colombia) through a Nexus+People Approach

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In recent years, Latin American countries have manifested a growing interest towards urban agriculture (UA), which can be employed as a nature-based solution to foster urban resilience; however, there are currently no unanimously recognised methods to assess its impacts. UA has had an established role in the development of Bogotá (Colombia), where it was first adopted in 2004 to counter the food insecurity of the lowest income groups of its population; nevertheless, studies that quantify its quantitative and qualitative impacts are lacking. The five-country FEW-meter study estimated the multi-dimensional effects of urban agriculture through a nexus approach based on citizen science. This study gathers and analysis data from 74 case studies in Europe and North America, measuring their consumption of water and energy, their production of food, and the social impacts generated. This paper discusses how the FEW-meter was applied in Bogotá, and what its outcomes were from both a quantitative and qualitative standpoint. In particular, an overview on the adaptation of the methodology to the context of Bogotá will be provided, followed by the description of the data gathering process, and results. This work contributes to the current discourse on the role of UA in the Global South on three levels: firstly, it delivers novel data on the productivity potential of this practice in a metropolitan context. Secondly, it addresses the often-overlooked topic of the socio-cultural effects of urban farming in the Global South by seeking to quantify them. Lastly, it elaborates on the need of developing local tools for global needs by adapting a methodology developed in the Global North to the specificities of a case study located in the Global South.

A Framework to Identify Conservation Priority Areas for "30x30" Target while Ensuring Food Security in a Cost-Effective Way
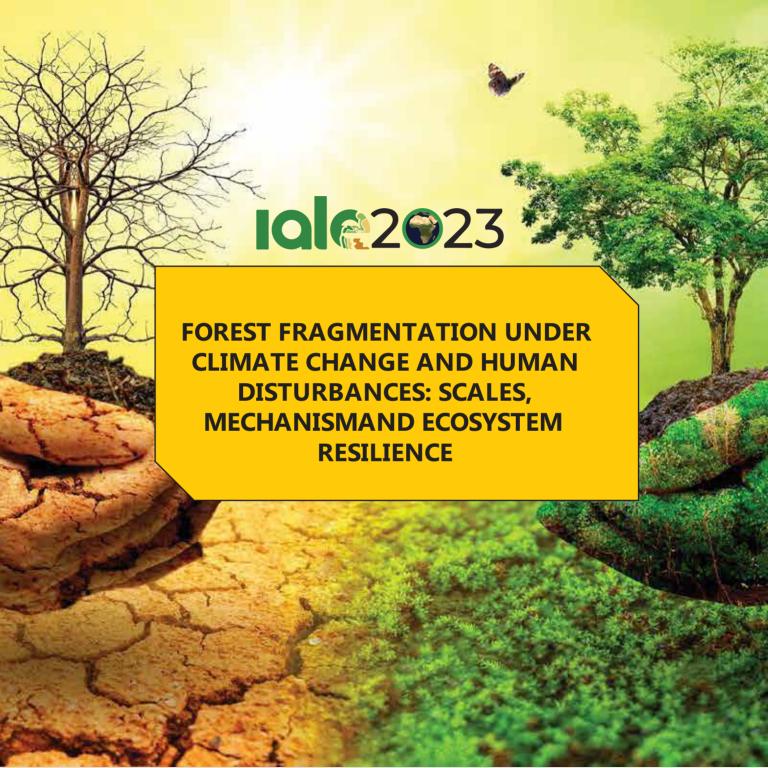
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expanding protected areas and OECMs in China while excluding current and predicted cropland for food security in two scenarios. The results indicate that China could expand protected areas to 22.81% of its land area in conservation priority areas with low human impact, and establish OECMs in areas accounting for 8.73% and 16.67% of the country's land area in a cost-effective approach in two scenarios. In the ambitious scenario, protected and conserved areas could cover up to 40.18% of terrestrial area, partially or completely covering the habitat of 2,392 (99.13%) species with an average coverage of 44.65%. This framework could be applied by countries to identify their protected areas and OECM expansion priorities and achieve post-2020 biodiversity conservation goals.

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FOREST FRAGMENTATION UNDER CLIMATE CHANGE AND HUMAN DISTURBANCES: SCALES, MECHANISMAND ECOSYSTEM RESILIENCE

Attractiveness of area Exclosures as a Carbon Sinks in N. Ethiopia

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Area exclosure in the Ethiopian context can be defined as the degraded land that has been excluded from human and livestock interference for rehabilitation. Establishment of area closures have been an important strategy for the rehabilitation of degraded hillsides. This practice has become very common, especially in the highlands of Ethiopia, due to the impressive improvement of productivity and reduction in soil erosion in the areas exclosed in the early 1980s. Exclosures has been recognized as promising practice in the rehabilitation of degraded land and providing various ecosystem services. Objective and research question: The primary objective of the research was evaluation of carbon sequestration and economic valuations in particular with the establishment of exclosures. The concept of the exclosure establishment has advanced importance more than this experiment and on biodiversity conservation of the whole landscape. The research also tries to answer: At what ecological conditions is the restored vegetation found? What sort of ecosystem services obtained maximal and in which age of the exclosures? Methodology: Exclosures of 10, 15, and 20 years old were selected and each exclosure was paired with an adjacent free grazing land. A total of 120 quadrants were sampled using a stratified preferential sampling design technique with flexible systematic model and 180 household respondents were surveyed with multi-stage stratified random sampling procedure incorporating household's survey questionnaires, focus group discussions, and key informants discussions were used to interpret the whole results in general.Results: All exclosures displayed higher ECS, and plant species richness, diversity and aboveground standing biomass than the free grazing lands. Differences in ECS between exclosures and free grazing lands varied between 32.96 and 61.0 tha-1and increased with exclosure age. Over a period of 20 years, the carbon dioxide sequestered in the investigated exclosures was 223.88 tha-1, total soil nitrogen increased by 2.93 tha-1 and additionally available phosphorus stocks amounted to 40 Kg ha-1. In exclosures, much of the variability in vegetation was explained by altitude and soil chemical properties like Mg, P, and K. But in free grazing lands altitude have the highest contribution. Differences in plant species richness and aboveground standing biomass between exclosures and free grazing lands also increased with exclosure age. Moreover, edaphic (e.g., soil total nitrogen, available phosphorus, CEC, exchangeable bases, soil pH and soil texture) and site (e.g., Stoniness, Grazing) variables will help to optimize the selection of areas for the establishment of future exclosures. Furthermore, the majority of the respondents had positive views on the effectiveness of exclosures to restore degraded soils and vegetation. The empirical results from binary logistic regression model showed age, tenure, farm size, off-farm activities and credit

access were positive and significant predictors and livestock number is negatively affected the sustainability of exclosure establishment and management practices. However, the respondents were concerned about the negative consequences of establishing exclosures such as reduction in the availability of fuelwood and shortage of grazing areas for their livestock. Our study showed that the establishment of exclosures on degraded free grazing lands in the northern highlands of Ethiopia is a viable option to restore native vegetation composition, richness, diversity and aboveground biomass. Consideration of edaphic (e.g., soil total nitrogen, available phosphorus, CEC, exchangeable bases, soil pH and soil texture) and site (e.g., Stoniness, Grazing) variables will help to optimize the selection of areas for the establishment of future exclosures. Moreover, our study suggests that with time exclosures may increasingly obtain an important role as refugees and species pool similar to church forests and should be protected and managed in a sustainable manner. However, economic and social impacts of exclosures should be included in feasibility studies before establishing exclosures in the future. The results of the present study confirm that establishment of exclosures on degraded free grazing lands in the Northern Highlands of Ethiopian is a viable option to restore ECS. Our study showed that ECS in exclosures, in free grazing lands and the change in ECS following the establishment of exclosures on free grazing lands can be predicted using easily measurable biophysical and management-related indicators. Such information is necessary for the establishment of baseline information for carbon sequestration projects, for evaluation of whether exclosure establishment should be expanded, and for policymakers to take into account the value of exclosures in their management decisions. Although our study showed that exclosures are effective to restore ECS, expansion of exclosures would increase grazing pressure on the remaining free grazing area. Therefore, the decision to establish additional exclosures should also include an economical analysis and an evaluation of the social consequences of such a decision.Discussions and recommendations: Although our study showed that exclosures are effective to restore ECS, expansion of exclosures would increase grazing pressure on the remaining free grazing area. Therefore, the decision to establish additional exclosures should also include an economical analysis and an evaluation of the social consequences of such a decision. The positive views of the majority of the respondents on exclosures imply that there is a substantial opportunity to mobilize the local communities in the efforts to manage the existing exclosures in a sustainable manner and to establish exclosures in the future. Yet, before expanding the area covered by exclosures, it is crucial to consider forest management options such as enrichment plantation of indigenous woody species that grow fast in exclosures to address the shortage of fuelwood and to lessen the shortage of grazing area.

Comparing Process- and Pattern-Based Measures of Landscape Fragmentation

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Improving the sensitivity and utility of quantification methods for assessing landscape fragmentation can benefit diverse practitioners, including landscape ecologists, planners, biodiversity assessors, or wildlife managers. Fragmentation is a complex concept that numerous pattern-based metrics strive to quantify, but why not focus on a process-based fragmentation metric instead when the aim is to understand the link between that process and fragmentation? We develop a series of new process-based fragmentation metrics that we then compute in conjunction with competing pattern-based metrics on simulated landscapes across a range of stationary and isotropic input parameters that control landscape composition and configuration; we then compare the quantified results. Our simulations produce binary landscapes that present the relatively simple, yet common, classifications of grid cells into low and high traversing costs for a hypothetical species. We then use a least cost pathway analysis, computed for random start and end points along the western and eastern margins of the landscape respectively and compute the number of steps, the total cost of traversing, and other derivative metrics that summarize the fragmentation of the landscape. We then compare these new fragmentation metrics with existing pattern-based metrics, and the known landscape simulation parameters to assess similarities, differences, and ranges where the sensitivity is greater. Results indicate that metrics from both pattern-based and process-based origins are more sensitive to landscape composition than configuration. The relationships between process-based and pattern-based results are highly non-linear, indicating that they measure subtle differences in the landscape and thus offer different insights into degrees of fragmentation and that a critical point of about 55% of cells requiring a high cost to traverse plays an important role in these assessments.

Canopy Cover and Fragmentation Response to Environment in Semi-Arid Mountains: A Case Study of the Yinshan Mountains, China Based on Google Earth Images

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The scale effect of remote sensing data leads to large errors in the estimation of forest canopy coverage in semi-arid areas, which affects our understanding of the relationship between forest and climate at regional scales. In this study, we took the Yinshan Mountains in Inner Mongolia, China as an example. We developed an automatic classification algorithm based on Google Earth images to identify forest canopy at the sub-meter scale, and compared the classification obtained with the forest categories from existing global land use dataset (FROM-GLC10 and Globeland30). Forest canopy data obtained by our method has accuracy close to 90%. The FROM-GLC10 and Globeland30 datasets underestimated the forest area by 21.06% and 16.88% respectively due to severe fragmentation of the canopy, and the underestimations mostly concentrated in warmer and drier areas. We found that temperature explained canopy fragmentation better than

precipitation, and that the canopy spatial distribution was more sensitive to climate variations than canopy coverage. This study provides a method to explore sub-meter canopy patterns at regional and landscape scales, and it can help guide mountain afforestation in semi-arid areas by explaining the relationship between canopy patterns and the environment.

Key words: Canopy fragmentation, Forest coverage, Google Earth images, Scale effect, Semi-arid mountains

Independent Effect of Habitat Configuration on Biodiversity along Gradients of Habitat Amount

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The negative effect of habitat loss on biodiversity is undisputed, while the effect of habitat fragmentation per se (i.e., the spatial configuration of habitat) has been debated for decades. However, it is important to move from debating whether fragmentation matters or not, to developing a more comprehensive understanding of when and how fragmentation matters. Here we aimed to test whether the effect of spatial configuration of habitat on species richness and functional diversity (FD) of different light tolerance or light demand is significant, and whether the significant effect only occurs when habitat amount (percentage of forest cover) is low. Based on 104 survey plots (1 km2) of vascular plants on the Swiss Plateau, we modelled the independent effect of habitat amount and habitat configuration (measured as number of patches, total edge, and proximity index) under all plots and three habitat amount classes: <10%, 10-30%, >30%. Results showed that after controlling the habitat amount, the habitat configuration significantly affect the species richness. The significant effects on species richness and FD occurred only when habitat amount is lower than 10%. Additionally, the response of plant to habitat configuration differs with different shade tolerance or light demand of species, as well as different diversity measurements (e.g., species richness and functional diversity). The diverse results revealed that considering confounding factors is of core importance in understanding the effects of habitat configuration on biodiversity and that generalizations are, at least so far, not possible. The on-going intense debate on the independent effects of habitat fragmentation highlights the need to explore more empirical evidence supporting our understanding and decisions. Further studies that consider functional traits and different aspect of biodiversity in different ecosystems might support the discovery of general patterns.

Diverse Responses of Radial Growth of Mongolian Scotch Pine Plantations to Extreme Droughts in Semi-Arid Regions in the Northern China

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Global warming has triggered more frequent and intense drought events, poured great pressure on the growth of forests. The vast semi-humid and semi-arid regions of northern China are part of the ecotone

between forests and grasslands, highly sensitive to climate warming. Forest fragmentation characterized landscape patterns in these regions, mainly driven by moisture gradient and human activity intensity, including the afforestation program of the largest scale in the world over past half century. Mongolian Scotch pine (Pinus sylvestris var. mongolica) is the most widely planted conifers in this region. In this study, the growth suitability of Mongolian Scotch pine was explored. Three typical climate regions were classified according to tree-ring information of growth response to climate: cool-humid (Type1), warm-drought (Type2), and hot-dry region (Type3), respectively. Three droughts with different severity were identified from 1980-2020, by both scPDSI and growth reductions. We calculated and compared the resistance (Rt), recovery (Rc), and resilience (Rs) of plantation populations. The results showed that: 1) Mongolian Scotch pine in Type1 regions could revert to pre-drought growth levels within 3 years after drought events; conversely, plantations inhabiting Type2 and 3 regions showed a lower resilience (p < 0.05) after more severe droughts; 2) the growth of plantations in Type2 showed a significant declining trend (p < 0.001) and plantations in Type3 declined insignificantly, while forests in Type1 grew stably in the recent 30 years; 3) plantations in the driest climate were more sensitive to high temperature and year-round climate drought, but were more related to climate factors in the growing season in other two regions. Furthermore, high level pre-drought growth weakened the Rs indices in all different drought events. The post-drought precipitation has promoted the Rc and Rs of plantations, compensating for the growth deficit caused by droughts. The Rt and Rs to droughts decreased significantly with age (p< 0.005). Controlling the age of plantations seems to be crucial for effectively maintaining the drought resilience of large-scale plantations and maximizing ecological benefits.

Vulnerability of Fragmented Temperate Dry Forests in Sanbei Region of China Impacted by Climate Change and Human Activities

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Arid and semi-arid regions, which make up 45% of the world's land, are considered to be the most vulnerable areas in response to climate change and human activities. China's Sanbei Region, known for its arid and semi-arid climate, has suffered severe environmental degradation and ecological damage caused by deforestation, desertification, and soil erosion resulting from intensive agriculture and overgrazing. This study aims to identify vulnerable areas of forests in the Sanbei Region using an ecological vulnerability assessment methodology that incorporates IPCC AR3/AR4 sensitivity concepts. The study assessed ecosystem vulnerability in fragmented forest areas using exposure assessment to climatic drought, vegetation change sensitivity, and tree age. We also considered adaptive corrections for local topography, soil thickness, and vegetation functional type, combined with tree height ranges at a spatial resolution of 30m. By combining these results with the findings of geographically

weighted regression, key factors influencing vulnerability were identified. These findings provide a scientific basis and data support for ecological restoration of climate vulnerability in fragmented forest areas. The forest vulnerability assessment revealed that forests in the Sanbei Region face various threats and challenges, including habitat fragmentation and climate change. Based on the results, the study identified three forest zones (Northwest, Northeast, and South) within the forest area. Within each zone, areas of relative vulnerability were identified where fragmented forest ecosystems are particularly vulnerable to disturbance and degradation due to more sensitive vegetation changes and lower tree ages. The study recommends implementing appropriate management and conservation strategies to protect and conserve vulnerable areas in the forests of the Sanbei region in arid and semi-arid areas. These strategies should focus on minimizing human impacts on young forest ecosystems, promoting sustainable forest use, and increasing ecosystem resilience to future changes.

Forest Fragmentation Patterns Related to Precipitation Gradient in Northern China: Scale Dependent Effects of Environment and Human Activities

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Landscape fragmentation is a prominent phenomenon in nature, jointly shaped by environmental heterogeneity and disturbance processes. The isoline of 400mm annual precipitation is long believed to be a threshold of forest distribution, indicating a transition from semi-humid to semi- arid temperate climate and reflected by prominent intensification of forest fragmentation along this line. However, the scale-dependence of the forest fragmentation pattern has never been articulated, and the dominant factors regulating the spatial heterogeneity of the fragmented patterns is unclear, posing a practical challenge to the feasible strategy of forest conservation and sustainable afforestation, given that China has implemented the world's largest afforestation project in the marginal areas in the temperate dry regions. This study explored the scale- dependent forest fragmentation patterns in the semi-humid to semi-arid temperate regions in northern China, using 10 m resolution land cover data (FROM-GLC10) to extract all forest patches along the annual precipitation (AP) isolines of 200mm, 250mm, … , 550mm, 600mm, calculated forest area percentage and fragmentation indices, and related the pattern to environmental factors (topography, soil, MAT) and human activities (road density, population density) using random forest model. We found the distribution of forest patches across the whole moisture gradient, with unimodal patterns of both area coverage and fragmentation intensity. The highest forest coverage corresponds to AP isoline of 450 mm and the lowest forest fragmentation occurred along the AP isoline of 500mm. Climatic drought is regulated by topography at local scale in dominates the forest fragmentation patterns on the drier side of 450mm AP isoline, but

human activities intensity dominates the fragmentation and forest coverage on the more humid side of the threshold. Our results highlight the importance of integrating climate change and human factors in predicting the response of forest to projected future climate scenarios.

Key words: forest fragmentation, annual precipitation threshold, scale-dependent pattern, topography, climate change, human activity

The Effect of Disturbance on Landscape Structure in Rural Landscapes in Sumedang Regency, Indonesia

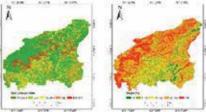Anwar Nasrudin[1,2], Parikesit[1,2,3], Susanti Withaningsih[1,2,3]

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Using the land-use maps of rural landscapes in Sumedang Regency, Indonesia, landscape structure and function in terms of the size and number of patches are analyzed, and the characteristics of the disturbance regime due to toll-road infrastructure development and increasing human settlements creating each landscape are discussed. Landscape structure in the research area is heterogenous because factors altering the landscape structure are complex. This heterogeneity is established and maintained by the agricultural land (rice-field and mixed-gardens/agroforestry) and natural disturbances such as forest fire and drought in dry season. The aim of this research was to determine the types of landscape structures and land use in the area, as well as changes in land use and land cover (LULC). The method used was a quantitative approach with descriptive analysis, and the data were collected by direct observation through ground check to the research site using a purposive sampling method, as well as digital observation through the Google Earth Pro processed by ArcGIS Pro. The main structures in landscape consisting matrices, fragments, and corridors are found in all rural landscape which consist of ten villages. The landscape mosaic was characterized by the relatively large patches composed of mixed gardens (talun) and garden. This is the result of the community-based forestry activity. Likewise, settlements, rice fields, fields, and shrubs were the fragments and the corridors were roads, water canals, and rivers. The vast majority of the land use in the rural region was used to produce timber for trade, then spices, rice, and other crops for personal consumption. Changes in land use could be seen over a ten-year period, from 2001 to 2021. The complexity of the physical, biological and anthropogenic factors makes the landscape unique to each region.

Keywords: disturbance; land use; landscape function; landscape structure; rural landscape

Synergistic Effects of Cyclones and Forest Fragmentation: A Before-After Study of Tropical Cyclone Yaas in Coastal Forests of Eastern India

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Yaas, a very severe cyclonic storm with a wind speed of 155 km h-1, made its landfall along the eastern coastal region of India (near Dhamra Port in Odisha) on May 26, 2021, accompanied by heavy storm surges and high-intensity rainfall, thereby wreaking havoc to the surrounding landscape. The present study attempts to examine the extent of storm-associated damage, how it varies spatially, and the potential interactions between cyclone Yaas and fragmentation patterns, in the Bhitarkanika National Park and Jambu Dweep area, which is nestled between the Brahmani and Mahanadi rivers. The Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), and pertinent landscape metrics of patch and class levels derived from these indices for the study region from the shore (Segment I) to the inland (Segment V), each of 2 km width, were derived using Landsat 8 data of pre and post-Yaas conditions. The findings exhibited that for all the segments, even the maximum NDVI values of the post-cyclone scenario were either less than or equal to the mean NDVI values of the pre-cyclone scenario. Decrease of SAVI values confirmed this trend and specifically pointed out the loss of tree canopy cover. Extensive damage was identified along Segment I, perhaps because of the additive effects of the west-moving air at the southern eyewall combined with the cyclone's rapid north-westward movement. Most fragments were south of the cyclone track, as a consequence of spatially selective forest cutting anf thinning practices, and therefore, showed the greatest damage. The canopy gaps underwent significant alterations, before and after Yaas, with an accelerating trend after the cyclone, leading to a statistically significant alteration in the forest's gap dynamics. Furthermore, segment-wise restoration practices were prescribed towards revitalizing the vegetative patches for maintaining regional environmental resilience.

Keywords: Environmental disturbance, Fragmentation metrics, Landscape transformation, Canopy gap, Vegetation health

Evolutionary Adaptation, Speciation and Resilience Within the World's Most Rapidly Radiating Bird Genus Zosterops

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Understanding drivers of species evolution, including population divergence, local adaptation and speciation are fundamental to identifying species vulnerable to extinction through environmental challenges and landscape change. In some cases, colonisation of populations to new habitats or isolation through habitat fragmentation can result in the formation of new

species over time. On the other hand, genetic bottlenecks and lack of gene flow between isolated habitat patches, as a result of these processes, may be a major evolutionary driver of species vulnerability and extinction. Here, we use whole-genome resequencing to investigate the processes shaping rapid divergence and speciation in the world's most rapidly radiating bird genus, Zosterops (White eyes), across lowland and highland landscapes in Kenya. Using pairwise species comparisons, we first provide detail on population history and divergence timeframes across the species' and identify environmental drivers of divergence and speciation. Pairwise FST across the genome identify strongly divergent 'genomic islands' between species likely due to strong adaptation to different habitats. We ask whether whole genome sequences suggest similar patterns of ecological adaptation across geographic and temporal scales in avian species evolving in different ecological contexts. Then, using the IUCN red-listed Taita White eye (Zosterops silvanus), a species whose range has been severely reduced and fragmented due to logging, we investigate the genetic diversity of the species and gene flow between forest fragments. Together these analyses develop an understanding of White eye population dynamics through landscape change at broad and local scales, which may be critical to ensuring species' persistence through anthropogenically and climatically altered landscapes.

Climate, Fires and Human Activity as a Regulator of the Landscape Dynamics in the Ural Region During the Holocene

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The impact of climate and human activity on landscape dynamics is a topical issue of modern paleoecological research since modern landscapes are the product of natural processes and human impact. Human-environment interplay is especially distinct at ecological borders of human existence, characterized by harsh climate conditions like in the boreal forest region. We present a high-temporal resolution vegetation, fire and land-use history in the poorly studied mid-Kama region (Urals, Russia). We applied radiocarbon dating, loss-on-ignition, micro- and macro-charcoal, pollen, and non-pollen palynomorphs of the Shabunichi-I peat core, covered the last 9200 years. These data we compare to archaeological and archaeobotanical findings from the mid-Kama valley. The reconstructions demonstrate the distribution of Siberian taiga landscapes with forest-steppe areas in the early Holocene under dry climate conditions, which led to intensive fire events. Climatic humification in the mid-Holocene promoted the spread of spruce and broad-leaved species along with decreased fire cases. Since 4000 cal yr BP, broad-leaved species maximally entered regional forests simultaneously with the occurrence and spread of Siberian fir. The first signs of anthropogenic landscape changes in the region evident in the Bronze Age (3900 cal yr BP). However, only since the Iron Age (2000-1600 cal yr BP), landscapes were strongly influenced by

anthropogenic activity and human-induced fires. The medieval migration of cultures to the north and south of the territory reduced the anthropogenic pressure on the mid-Kama ecosystems until the last 500 years. Our research of the environmental evolution in mid-Kama region provide important insights in human-environment interactions in the past and evaluate human impact on the ecosystems in boreal region.

Vegetation-Human Interactions in the East-European Forest-Steppe Over the Holocene

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East-European forest-steppe ecotone was inhabited and actively used by people since Palaeolithic. During the Holocene, the land use dynamics of the ecotone was changing from forager communities to nomadism and agricultural societies. Around 7.3-7.2 kyr BP Neolithic revolution reached the western part of the region and was spreading eastwards for the next ~2 kyr. Unique position of the forest-steppe at the junction of two different natural zones allowed the coexistence and interchange of cultures with different types of economy, and each of them impacted the landscape differently.In 2013 we obtained Omelchenki sediment core (Kharkiv region, Ukraine) from the southern border of the East-European forest-steppe ecotone. Nine radiocarbon dates insured the robust age-depth model. Palynological, non-pollen palynomorphs', macroremains', charcoal and loss-on-ignition analysis allowed us to reconstruct the vegetation and fire dynamics due to the climate and human impact over the last ~9.4 kyr BP. Using the modern analogue technique, we reconstructed the forest cover of the area. We conclude that the Holocene climate and environmental changes supported the changes in subsistence bases throughout the Holocene. Thus, in the first half of the Holocene the fluctuations of the southern tree line correspond with the changes of the cultures with forager economies. The mid-Holocene spread of steppe promoted stock breeding as a basis of the Copper Age cultures' economy. The early late-Holocene increase in available moisture and the following forest spread contributed to the transition from nomadism to farming. Our data highlight a high sensitivity of forests in their southern limits to anthropogenic pressure, which emphasizes the possibility of their potential spread further south. However, considering the current global warming the southern tree line is likely to shift northwards bringing the area to the mid-Holocene conditions increasing risks for agriculture.

Does Forest Cover Change Influence Drought Resilience? A Case Study of Greater Panna Landscape, Central India

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Understanding interactions and feedback between biological processes and climatic regimes is essential but is usually not incorporated into climatic models. To

forge climate change mitigation policies, the inclusion of landscape change is a must as it reflects human-nature interaction. The present study aims to understand the landscape-level change in forest cover and its relationship to drought resilience in Greater Panna Landscape (GPL), Central India. GPL covers an area of 47621 sqkm. in the states of Madhya Pradesh and Uttar Pradesh; and is home to over >15 million people. We quantified forest cover changes from 1990 to 2020 using Landsat data. We used the Standard Precipitation Index (SPI) calculated from the gridded rainfall data (1990-2020) and MODIS vegetation products for drought resilience assessment. Lastly, we ran a geographically weighted regression model to investigate the relationship between forest cover change and drought resilience. The results of landscape-level change analysis represent that 75.1% of the total area of GPL is attributed to other land uses, 13.4% is covered by unaltered forest, 9.3% by forest growth, and 3.8% by forest degradation. Drought-resilience assessment predicted that the western part of the landscape is non-resilient, whereas the eastern and north-eastern parts were predicted to be resilient. The regression model revealed a positive relationship between unaltered forest, forest growth, and resilient areas, while climate variables were tested insignificant. The current study highlights the degraded areas which can be prioritized for restoration activities to mitigate adverse climatic conditions in order to develop a resilient ecosystem.

Can Landscape Structure Increase the Resilience of Pollination Services in Face of Climate Change?

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Pollination is fundamental for agriculture and biodiversity, but the homogenisation of intensely explored landscapes is among the leading causes of pollinator declines. Decreased agricultural productivity due to pollination deficit may force farmers to increase crop areas, generating pollinators-productivity loss feedback cycles. Climate change may accentuate these landscape change effects, aggravating the current pollination services crisis. To cope with this, we need to understand if the future distribution of pollinator communities will match the exact locations where their native habitats will be available to guarantee services provision. We used MaxEnt niche models for 172 South American bees with more than 1000 registries (GBIF and SpeciesLink) using the historical and projected WorldClim bioclimatic variables standardised according to the IPCC Shared Socioeconomic Pathways (SSP1-3 and 5). Continuous occurrence probabilities were taken as proxies of climate suitability and bee diversity. To get future relative changes, we subtracted the current from the future bee diversity estimates. These changes were correlated to future landscape structure estimated from the Land Use Harmonization 2 layer. Our results show that climate change may negatively affect bee diversity, especially in the highest emissions and global warming scenarios (SSP3 and 5). Most Latin America (>50%) may

experience bee diversity loss between 30 and 60%, reaching up to 80% in the worst-case scenarios. But the landscape structure may play a role in buffering climate change effects for >60% of Latin America, showing that proper landscape planning is crucial to mitigate bee diversity and pollination services losses in the global south.

The Position of Temperate Forests In Relation to Agricultural Land Affects Soil Carbon Stocks and the Stratification of Soil C:N Ratios

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The ability of forest ecosystems to sequester and store carbon is an ecosystem service vital for climate change mitigation. However, the ability of temperate forests to scavenge reactive nitrogenous compounds emitted to the atmosphere from agricultural land disrupts nutrient cycling processes, root biomass and soil biodiversity, which are tightly linked to soil carbon cycling. Transect studies conducted at a site scale have previously observed that the effect of agricultural emissions is greatest at the forest edge.Here we collated a European-scale dataset from published literature of forest organic and mineral soil C:N ratios, pH, nitrate deposition and nitrate leaching, including representation of sites located up to 1000 m away from agricultural land. The difference between organic and mineral soil C:N ratios was widest in forest soils located 500-750 m away from agricultural land. The pH of organic soils located 500-750 m from agricultural land

was significantly higher than soils located closer to agricultural land.To investigate the effect of proximity to agricultural land on forest soils further, we analysed data from a field study in Thetford Forest, UK. Carbon stocks in deep mineral soils (60-90 cm depth) significantly decreased with increasing distance from arable land, whilst nitrogen stocks did not change significantly. It is hypothesised that the decrease in carbon stocks is related to observed changes in deposition and the increased rate of soil nitrification with proximity to agricultural land.This research highlights that the position of temperate forests in relation to agricultural land affects the capacity of forests to store carbon and deliver soil-related ecosystem services.

Time Series Analysis of Satellite Data for Early Detection of Changes in Ecosystems in Tanzania

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Traditionally, changes in land cover are used for the assessment of alternations in the ecosystems. Although such approach is very popular land cover changes reflect only very evident variations in the environment, usually caused by humans. A natural evolution of ecosystems, e.g. related to the climate change, is relatively slow and does not appear directly in land cover status. This process can be reflected in changes in functioning of ecosystems or in their biomass. Satellite

remote sensing delivers a huge amount of data, which allows regular observations of the environment. This work presents a method for satellite monitoring for early detection of changes. We use time series of optical and radar Sentinel images to map Ecosystem Functional Types (EFT) in west northern Tanzania for years 2016-2022. We modified the EFT concept to analyse not only photosynthetical activity of vegetation, but also changes in its water content and biomass. Basing on four-dimensional analysis of vegetation (time, photosynthesis, moisture and biomass) we establish areas, which are under a stress and undergo changes. We compare our results with the traditional land cover maps elaborated year by year for the study period to show how fast we detect the first symptoms of the alternation in ecosystems before it results in land cover change.

GEOAI, MACHINE LEARNING, AND BIG DATA ANALYSES 0F EARTH OBSERVATION DATA FOR CLIMATE CHANGE AND ECOSYSTEM RESILIENCE

Does Forest Certification Reduce Deforestation in Logging Concessions in Tropical Moist Forests?

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The degradation and deforestation of tropical forests pose significant challenges to climate change mitigation, biodiversity conservation, and livelihoods. Recognition of the gravity of these problems has led to the introduction of several instruments targeting sustainable forest management. One such instrument is forest certification, which aims to reduce forest degradation and deforestation while enhancing forest enterprises' economic viability. However, little research has been done on how forest certification is meeting such objectives in tropical forests, especially regarding impacts on deforestation on larger spatial and temporal scales. We conducted a cross-country study, including Indonesia, Peru, and countries in the Congo basin, to assess the impact of Forest Stewardship Council (FSC) certification in reducing deforestation in logging concessions of tropical moist forests over three decades (1991 – 2021). Applying a quasi-experimental approach in which we combine spatial analysis, propensity score matching, and difference in difference estimation with staggered treatment timing, we assess the impact of FSC certification over time, accounting for both deforestation trends before and after certification, as well as between certified and uncertified concessions. While we found that FSC certification reduces deforestation on a cross-country scale by 0.002% per unit, or 125 ha (1.25 km²) per year, we found no effect on the individual countries' scale. This shows that the impact of FSC certification across countries and over time is unclear. We suggest that more development in data and methods is needed to track the progress of forest certification impacts.

Keywords: Forest stewardship council, policy effectiveness, impact assessment, cross-country, geospatial

Bat Sonotype As a Novel Insight into the Congo Basin Rainforest Dynamic

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Tropical forest ecosystems are undergoing an exponential regression of their surface areas with subsequent habitat loss and fragmentation. The effects of such disturbances on bats are quite significant, even leading to a decline in populations. In order to ensure the maintenance of bat populations, it is thus important to preserve their habitats. This involves highlighting preferential habitats but also factors related to their foraging sites.

We have combined acoustic surveys and capture-mark-recapture methods to study relationships between bats and their preferred habitats and also to identify functional role of bats captured or recorded in their habitat. A total of 42 bats were captured, belonging to 13 species, including 5 species of frugivorous bats and 8 insectivorous bats.The frugivorous bats - namely the species Scotonycteris bergmansi, Casinycteris arginnis, Myonycteris torquata and Epomops franqueti - were associated with dispersal of 16 plant species in the Yangambi Man and Biosphere Reserve (Aidia micrantha, Allanblackia floribunda, Anonidium mannii, Barteria nigritana, Canarium schweinfurthii, Coelocaryon preussi, Dacryodes edulis, Mammea africana, Maranthes glabra, Microdesmis yanfungana, Musanga cecropioides, Pycnanthus angolensis, Staudtia gabonensis, Strombosia grandifolia, Strombosiopsis tetrandra and Panda oleosa) while the species Megaloglossus woermanni ensures the pollination of the species Maranthes glabra.Acoustic monitoring revealed the presence of 11 sonotypes namely of the following species: Chaerephon pumilus, Macronycteris gigas, Macronycteris vittatus, Doryrhina cyclops, Rhinolophus fumigatus, Neoromicia nana/Scotophilus dinganii, Pipistrellus nanulus, Pipistrellus rueppellii, Nycteris arge, Myotis bocagii and Glauconycteris superba. The type of habitat (primary forest) significantly increases the foraging activity of bats. A medium to high density of the understorey and a medium opening of the canopy have a significant influence on bat activity and call structure. Complementary of acoustic monitoring and capture is crucial to understand the mechanisms governing aggregation of bats assemblages in order to assess their activity and the ecosystem services they provide.

Modeling Invasive Plant Species in Kenya's Northern Rangelands

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Kenya is composed of diverse geographic regions and is heavily impacted by climatic variability. Habitat heterogeneity has led to a diverse number of plants and animals. Invasive species, however, threaten this biodiversity. This study mapped the current distribution of Acacia reficiens and Opuntia spp. using occurrence data, then applied a species distribution model to identify where suitable habitats occur under current and projected climatic scenarios under Representative Climate Pathways (R) 2.6 and 8.5. Occurrences of the two invasive plant species were sampled using an android-based application and a GPS (Global Positioning System) device. Predictor variables included: elevation, distance to streams and rivers, human population density, and vegetation indices (monthly

Normalized Difference Vegetation Indices (NDVI) and Enhanced Vegetation Indices (EVI) derived from MODIS products 1-km spatial resolution). The mean of 25 replicates was used in identifying suitable habitats. We evaluated model performance using the average test AUC, mean testing omission rate metrics, and mean regularized training gain. The predictive models for both species performed better than random chance ($p < 0.05$). Mean test AUC values of 0.96 and 0.97 for A. reficiens and Opuntia spp. respectively, were achieved and their associated 95% confidence intervals showed the fitted models realized the high discriminative ability to differentiate optimal conditions for invasive plant species from random pseudo-absence points. The mean test AUC results for A. reficiens (0.97 ± 0.02) and Opuntia spp. (0.985 ± 0.01) were regarded as high. The models yielded moderate test gain values of 2.4 and 2.7, respectively. The model predictions show the distributions of A. reficiens and Opuntia spp. may increase under future climatic scenarios; with current extents estimated at 339,000 and 183,000 ha, respectively, with projected future spread reaching 732,800 and 206,900 ha, respectively, by 2070. Data on mapping, monitoring, and assessment of the invasive species can provide governments with insight into how the poor and vulnerable people are affected by the loss and degradation of biodiversity and ecosystems due to the spread of such species. This information is key in achieving the Sustainable Development Goals 15 (SDG) of the UN, aimed at the protection, restoration, and promotion of sustainable use of terrestrial ecosystems. Keywords: invasive species, Maxent, modeling, prediction, species distribution modeling, climate

Application of Artificial Intelligence Algorithms to Monitor Desert Locust (Schistocerca Gregaria) Invasion at a Landscape Scale

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The horn of Africa experienced an unprecedented invasion of huge swarms of desert locusts (DL) between 2019 – 2020 that has never been witnessed in the past 70 years. The outbreak has threatened livelihoods, food security, environment, and economic development in the region. To prevent catastrophic outbreaks of DL swarms, it is critical to identify potential breeding grounds, migration patterns and frequency of occurrence for timely and effective management. Hence, this study applied artificial intelligence modelling algorithms to predict desert locust suitable habitats of breeding grounds and swarm outbreaks. The prediction models utilized key satellite-based bio-climatic variables (temperature, rainfall and wind speed) and landscape indicators on soil sand and moisture content, and vegetation productivity. The developed models accurately predicted (i) present suitable habitats for desert locust breeding and identified areas with

similar conducive future conditions with > 80% accuracy, and (2) the spatiotemporal pattern (where and when; month and year) of future desert locust outbreaks with an overall accuracy of about 60%. Moreover, the study reveals that vast areas in the horn of Africa have conductive environmental conditions to support the oviposition, breeding and outbreak of desert locusts. There is a need to target these high-risk areas to manage the pest in a timely, cost-effective, and environmentally friendly manner. Our study provides information for preparedness and prioritization of ground surveillance on desert locust breeding, outbreaks, invasions, and upsurges, and deployment of best-bet solutions for effective management of the pest. *Keywords: Insect pests; machine learning; decision support tools; East Africa*

Effect of Surface Temperature on Conversion of Agricultural Land to Solar PV System - Japan Kushida River Basin as an Example

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This paper uses machine learning and remote sensing techniques to observe the impact of temperature change on the watershed environment due to conversion of agricultural land in the Japanese Kushida River watershed in an integrated model. A time series from 2017 to 2022 was simulated to determine the location information of agricultural land being converted to PV system and to determine the 100m resolution to determine trends in surface temperature (LST) changes in individual watersheds. The results show that the average LST for May-June 2017 in the study area is 26.2℃ and 26.7℃ in 2022; the average surface temperature difference (LST-D) between the two-time points is found to be 0.51 ℃ (min -12.7, max 19.1) and This is higher than the Japanese government's projected five-year warming increase of 0.18-0.32, and the conversion of agricultural land was found to have a significant effect on surface temperature changes in the study area. The temperature in the area where farmland was converted to PV system increased by 1.8℃-11.5℃ during the crop growing season from March to June, and the impact varied depending on the size of the PV system and the surrounding environment. In addition, the impact decreases linearly with distance, but this decreases rate varies with local natural and anthropogenic factors. Using statistical analysis, we found that this rate of decline is particularly correlated with surrounding building density and elevation, among other factors. This shows that the conversion impact of agricultural land to PV system can vary greatly depending on the surrounding environment.

Excellence In Agronomy for Sustainable Intensification and Climate Adaptation: A OneCGIAR Initiative Rethinking Agronomy at Scale in Global South Through Data Sciences and Geospatial Technologies

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Smallholdings represent over 80% of the world's farms, mostly located in the Global South. Enhanced agronomy management has a great potential to increase

productivity, sustainability, efficiency and competitiveness of these smallholdings, which is characterized by low and variable yields and profitability, smallholder farming challenges include water scarcity, climate change, low resource use efficiencies and declining soil health. These result in negative impacts on food and nutrition security, equitable livelihoods and ecosystem health. The objective of the OneCGIAR Excellence in Agronomy (EiA) initiative is to modernize agronomy around sustainable intensification and climate change adaptation through the delivery of agronomic gain in the Global South. EiA proposes an original framework driven by the public and private sector demand through use cases that will generate evidence to develop widely applicable and locally relevant agronomic solutions at scale. To that end, EiA combines big data and data sciences analytics, new geospatial technologies and decision tools, and farming-system research to improve spatially explicit agronomic recommendations in response to demand from scaling partners. The EiA initiative will be illustrated through two use cases among the 20 involved. Digital Green in Ethiopia aims at developing and piloting location-specific fertilizer recommendation (LSFR) for wheat. A Random Forest predictive model was used to generate site specific fertilizer rate based on multisources remote sensing observation and has been validated on 300 farmer fields in 2021. Results from validation study showed that LSFR significantly improved wheat grain and straw yields, increased nutrient and water use efficiency, and farmers profit per investment in fertilizer. (2) The Gvt of Egypt use case that is developing a web-based actual yield and yield gap estimation for wheat and faba bean based on remote sensing biophysical variables, and the coupling of the APSIM crop model and machine learning algorithms.

Inter-Seasonal Estimation of Grass Water Content Indicators Using Multisource Remotely Sensed Data Metrics and the Cloud-Computing Google Earth Engine Platform

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Indicators of grass water content (GWC) have a significant impact on eco-hydrological processes such as evapotranspiration and rainfall interception. Several site-specific factors such as seasonal precipitation, temperature, and topographic variations cause soil and ground moisture content variations, which have significant impacts on GWC. Estimating GWC using multisource data may provide robust and accurate predictions, making it a useful tool for plant water quantification and management at various landscape scales. In this study, Sentinel-2 MSI bands, spectral derivatives combined with topographic and climatic variables, were used to estimate leaf area index (LAI), canopy storage capacity (CSC), canopy water content (CWC) and equivalent water thickness (EWT) as indicators of GWC within the communal grasslands in Vulindlela across wet and dry seasons based on single-year data. The results illustrate that the use of multi-source data, coupled with Random Forest in Google Earth Engine, improved the prediction accuracies of

GWC variables across wet and dry seasons. LAI was optimally estimated in the wet season with an RMSE of 0.03 m−2 and R2 of 0.83, comparable to the dry season results, which exhibited an RMSE of 0.04 m−2 and R2 of 0.90. Similarly, CSC was estimated with high accuracy in the wet season (RMSE = 0.01 mm and R2 = 0.86) when compared to the RMSE of 0.03 mm and R2 of 0.93 obtained in the dry season. Meanwhile, for CWC, the wet season results show an RMSE of 19.42 g/m−2 and R2 of 0.76, which were lower than the accuracy of RMSE = 1.35 g/m−2 and R2 = 0.87 obtained in the dry season. Finally, EWT was best estimated in the dry season, yielding a model accuracy of RMSE = 2.01 g/m−2 and R2 = 0.91 as compared to the wet season (RMSE = 10.75 g/m−2 and R2 = 0.65). The use of multisource data improved the prediction accuracies for GWC indicators across both seasons. Such information is crucial for rangeland managers in understanding GWC variations across different seasons as well as different ecological gradients.

Ecosystem Integrity – Sensor /EO-Service (ESIS) for Monitoring Bio- and Geodiversity by Spectral Traits and Remote Sensing Approaches

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Ecosystems fulfil a whole range of ecosystem functions. There are a variety of long-standing and standardised approaches to monitoring ecosystem health, bio- and geodiversity that increasingly integrate RS-based monitoring approaches. Unfortunately, these approaches to monitoring, data storage, analysis, forecasting and assessment do not yet meet the future demands of 21st century information and digital knowledge processing. If we are to understand the complexity of our system, we need to adopt a holistic RS monitoring approach. Traits and trait variations exist at all spatio-temporal scales. Traits are the crucial interface between different ecosystem domains, linking in situ and RS monitoring approaches, and are proxy indicators of ecosystem-human health interactions. RS traits can be used to quantify genesis, structural, functional and taxonomic geo- and biodiversity, vegetation health and land use intensity indicators. In this presentation we present the development of an "EcoSystem Integrity - RS/Modelling Service (ESIS)" tool (Selsam et al., 2022) for monitoring and quantifying indicatores of bio-and geodiversity by RS data (Lausch et al., 2016, 2022).

Estimating Above Ground Biomass and Carbon Stocks of the Budongo Tropical Rainforest Using Polarimetric Synthetic Aperture Radar (SAR) Interferometry

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Estimation of biomass is an important means for understanding the dynamics of a forest ecosystem and

the effect of forest disturbances on productivity and carbon storage of forest stands. In the recent years, there has been a growing interest in the possibility of using remote sensing to estimate carbon stocks in terrestrial systems such as tropical rainforests. Radar remote sensing is being adopted as a popular method for estimating above ground biomass over large areas because of its ability to penetrate through cloud cover and the forest canopy. There has been no regularized attempt to assess the carbon stocks for the Budongo Forest despite its importance in the national ecosystem. Research on carbon storage and absorption capability of the forest is thus very vital, to help in formulating emission reduction strategies for sustainable development. This study seeks to use Polarimetric Synthetic Aperture Radar Interferometry to estimate Carbon stocks over the Budongo Tropical rainforest. The technique has been adopted to reduce signal saturation, which is a major limitation in SAR remote sensing systems for higher biomass levels, to allow for a detailed characterization of Carbon stocks. Radar images of the study area are decomposed into higher order scattering mechanisms through polarimetric phase analysis. Thereafter, forest heights are derived by intereformetric differencing of two images of a scene acquired at different times. Field allometric measurements are used for training and validation. Above ground biomass and Carbon Stocks are then estimated through inversion and regression analysis. The model is still under development but preliminary results indicate a Carbon Stock estimate of 265.5 Mg/ha C for the forest. Final results to be ready by May, 2023.

Sustainability of Middle-Income Residential Neighbourhoods in Nairobi City County

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Sustainability is an important element in the planning of cities and urban areas, but has received less attention in the development of neighborhoods. The current growth in the Nairobi city has led to poor infrastructure, environmental challenges and overcrowding which has affected sustainability of neighborhoods. Given the impact of residential development on sustainability and current growth in the city, this study seeks to assess sustainability level of three middle-income residential neighborhoods in Nairobi. The neighborhoods are Buruburu, Zimmerman and Garden estate. Buruburu is a planned neighborhood but has changed due to informality, while Zimmerman is unplanned neighborhood with high density and Garden estate is a low-density neighborhood that is assumed not to have changed its characteristics over time. However, without any assessment on these types of neighborhood it is unknown which neighborhood is sustainable compared to other neighborhoods. Therefore, this study seeks to measure sustainability level of the three neighborhoods. Data for this study will be obtained from questionnaire and aerial imagery. Systematic sampling and simple random sampling will when administering the questionnaires. Questionnaires will be used to examine adequacy of facilities and assess sustainability level. The aerial imagery will be used to assess the environmental

sustainability of the neighborhoods. Statistical Package of Social Science will be used for statistical analysis in form of frequencies, percentages, regression and correlation analysis. Multiple regressions will be used to assess the effect of each indicator on sustainability level. Geographical Information Systems will be used for spatial analysis and image classification of Landsat images. The finding of this project will help in the formulation of guidelines that will guide planning and development of residential estates.

Vegetation Mapping with Multi-Source Data in a Global Biodiversity Hotspot Region

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Vegetation maps provide valuable information for ecologists and decision-makers regarding the spatial distribution of various vegetation types and ecosystems, but large-scale vegetation mapping and updating can be challenging with traditional mapping approaches. Recently, earth observation technologies and machine learning algorithms have allowed the generation of accurate vegetation maps on a large spatial scale. However, it is still difficult to create detailed and accurate vegetation maps in regions with strong environmental heterogeneity, high biodiversity, and frequent human disturbance. In this study, we offer a practical framework for vegetation mapping and validating in biodiversity hotspots with multi-source data. The spatial distribution of 17 vegetation types and 44 subtypes in Yunnan was mapped and validated. The accuracies of our vegetation map were much higher than those of other vegetation maps in this region. The high accuracies of our map are mainly due to various data sources, data-fusion based mapping approaches, and comprehensive understanding of Yunnan vegetation. This study updated knowledge about the vegetation distribution in Yunnan since 1980s and provided a comprehensive analysis of the patterns and drivers of vegetation dynamics. We found an obvious trend of vegetation restoration in both vegetation types and their conditions during the past 30 years. The combined effects of atmospheric and climatic change (A&C change) and conservation measures dominated vegetation dynamics in the Yunnan global biodiversity hotspot region.

Harnessing Computer Intelligence to Identify Optimal Sites for Climate-Smart Intercropping System in Africa

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The fall armyworm (FAW), Spodoptera frugiperda, poses a significant threat to maize crops. To counter this, a nature-inspired 'Push-Pull' strategy is employed. This method involves intercropping maize with non-edible legume plants (i.e., Desmodium and Brachiaria) to harness nature's balance to deter crop pests like FAW

from the main crop (push) while attracting them elsewhere using 'pull' plants. Another essential factor in the 'push-pull' strategy is the presence of livestock in the system. This not only enhances the ecological balance of the system but also benefits from the 'pull' leguminous fodder crops. This relationship creates a sustainable loop, benefiting both the main crop and the livestock. We designed a computational tool that identifies the optimal regions in Africa for implementing the 'push-pull' strategy at a landscape scale. Based on expert knowledge, the developed tool rates landscapes on a 0 to 1 scale for their 'push-pull' suitability, with 1 being highly suitable. Our findings suggest that all maize-growing landscapes in Africa are suitable for deploying this method. Regions in eastern and southern Africa are particularly well-suited for 'push-pull'. Interestingly, environmental elements like rainfall and soil nutrients play a key role than temperature in determining the 'push-pull' suitability. In conclusion, this study provides a valuable resource for decision-makers and farmers, spotlighting the 'push-pull' strategy's potential. Moreover, landscape planners and policymakers can promote sustainable farming practices and protect our invaluable agricultural landscapes.

Quantifying the Resilience of Surface Coal Mines Coupled with Disturbance Magnitude and its Response to Climate in China

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Resilience is the key to the success of ecological restoration and reconstruction in coal mining areas, recovery time is widely used in the assessment of resilience, but it is difficult to reflect the difference of recovery time under different disturbance magnitude. This study takes 46 surface coal mines in ecologically fragile areas of China as the study area, and uses the LandTrendr algorithm to quantify the resilience of surface coal mines by coupling recovery time and disturbance magnitude. Using geographic detector to reveal individual and interactive influences of climate factors on the resilience, and the attribution differences of surface coal mines resilience under different climate characteristics are further analyzed. Based on the resilience of surface coal mines and climate characteristics, differential strategy for ecological restoration of each surface coal mine is proposed. The results show that the range of resilience of 46 surface coal mines is 867.51-7220.59, showing a decreasing trend from east to west in space. Annual average atmospheric pressure and annual sunshine duration can explain the differences in resilience well. The superposition of the two climate factors will increase the impact on the spatial heterogeneity of surface coal mine resilience, and the interactive explanatory power of annual sunshine duration and annual average wind speed is the strongest. After interacting with other climate factors, annual average wind speed has a significant enhancement effect. Under different climate characteristics, the explanatory power of single and interactive factors is different. This study provides an important basis for coordinating climate conditions to enhance regional resilience and for sustainable development of coal mines.

Developing Agro-Ecological Spatial Unit with Earth Observation and Machine Learning to Scale Up Crop Yield Gap Analysis: Case Study of Rainfed Wheat in Ethiopia

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Despite wheat yields improvement observed in recent years, the current wheat yield in Ethiopia is only 20% of its potential. To be able to develop sustainable production systems that allow to address food security issue while decreasing environmental pressures, spatially explicit information on yield gaps and its determinants are needed. However, spatially explicit yield gap analysis at large scale has long been a challenging exercise due to the lack of reproducible and robust spatial frameworks. In this study, we relied on the agro-ecological spatial unit (ASU) concept proposed by FAO for assessing agricultural resources and potential. ASU are homogeneous spatial units, in terms of bio-physical and socio-economic parameters, which are assumed to respond similarly in terms of crop yield, and hence representing a baseline information to address the large-scale yield gap scaling-up challenge. The objective of this study is to develop ASU for rainfed wheat areas at national scale for Ethiopia relying on recent earth observation (EO) and geospatial data together with machine learning (ML) analytics. The study was conducted over the 2021-2022 cropping season. First, a wheat rain-fed map was produced under Google Earth Engine using Sentinel 1, Sentinel 2 indices and seasonal parameters, and environmental variables. Various ML algorithms were calibrated based on 1500 ground-truth data collected across the country. An accuracy of 97% in validation was obtained with the Random Forest algorithm. Second, ASU development is ongoing and consists of the comparison of two segmentation approaches, an object-based (top-down), and a pixel-based (bottom up) using Sentinel-3 data together with the rainfed wheat map and ancillary biophysical and socio-economic data. K-means clustering algorithm and its extension X-mean will be used in both approaches. The ASU approach will be validated by an intensive household survey conducted over Ethiopia on yield gap.

Introducing LandScaleR: A Novel Method for Spatial Downscaling of Land Use Projections

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Land use and land cover (LULC) projections do not always have sufficient spatial resolution to allow them

to be used by the broad range of environmental models that project how LULC impacts a range of variables, including ecosystem services, biodiversity, hydrology, and carbon emissions. We present LandScaleR, a downscaling method designed to generate the high resolution LULC projections often required for environmental modelling. The downscaling algorithm allocates LULC change to a high-resolution reference map based on the density of LULC classes in neighbouring grid cells and stochasticity in the placement of new LULC areas. The introduction of stochasticity into LandScaleR enables new patches of LULC to appear in a landscape during downscaling. LandScaleR recreated LULC patterns observed in Colombia, a highly biodiverse country with ongoing deforestation and loss of natural land covers, between 1960 and 2019. Increasing a parameter that controls the likelihood of cells adjacent to existing LULC classes being converted to the same class generated less spatially aggregated landscapes that better represented historic LULC patterns in Colombia. For many environmental models the spatial aggregation and configuration of LULC is as important to capture as the overall amount of LULC in a region. This new downscaling method is available as an R package and will enable the reconciliation of the spatial resolution of LULC projections and key processes that are embedded in a wide range of environmental models.

Building Community Resilience Through Vegetation and Water Management in Lagha-Bor Catchment, Wajir County Kenya

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Land use changes linked to demographic changes in Arid and Semi-Arid Lands (ASALs) presents a compounding challenge on vulnerable environment. Understanding of best catchment management practices is important in building communities' resilience on water security and environment depended livelihoods where poor and erratic rainfall remains coupled with frequent droughts are a norm. This study sough to assess potential vegetation, soil and water management interventions necessary to contain the rising environmental degradation and water security situation in Lagha Bor catchment. The catchment has occasioned accelerated development of water points leading to increased abstractions through boreholes with limited recharge. An integrated SWAT+ and groundwater module (gwflow) was applied in assessing the effects of surface and groundwater management measures. Among the most applicable approaches in the catchment included reduced and alternate grazing which could be achieved through relocation of animal watering points an extension of pipeline beyond 2 Km where vegetation pressures were highly felt. The application of water spreading structures can facilitate artificial recharge with additional potential benefits of improved irrigation for livelihood support. The combined effects of vegetation and water management was runoff reduction by 20% while hydrological components including lateral flow, percolation, evaporation, groundwater transfer and groundwater

recharge would increase by 6%, 24%, 13.5%, 58.6% and 25% respectively. Reduced rate of borehole development and abstraction management is necessary for better results. The study provides baseline information necessary in stakeholder engagement and a link towards development of sound policies and interventions for improved livelihood and water security.

The Dawn of a New Digital Agricultural Revolution in Africa

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African farmers are bearing the brunt of climate change and extreme weather events. Furthermore, subsistence farming can no longer feed the over 1.4 billion people on the continent. Therefore, new ways of farming are a matter of urgency to help farmers build resilience against the new pressures and improve yields. Satellite and drone remote sensing in combination with machine learning (ML) cloud-computing, smart phones and Internet of things (IOT) can be used to launch a new agricultural revolution in Africa. These smart technologies, when effectively used can help African farmers and agrobusiness entrepreneurs to achieve greater returns on agricultural production and agro-processing activities. For example, agricultural insights derived from remote sensing technologies could usher a new era of digital extension agricultural services and expand the implementation of precision agriculture on the continent. This paper presents the examples from South Africa.

Assessment of Herbaceous Forage Quality in Senegalese Rangelands Using Remote Sensing and Near Infrared Spectroscopy Data

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In the Sahel, livestock mostly depend on natural forage for feed. To ensure the sustainability of rangelands and the resilience of pastoral population to the climate change impacts, timely assessment of forage availability is essential. Currently, it is possible to monitor forage mass using remote sensing, but the assessment of their nutritional value remains unresolved especially during the dry season (October to May), the longest and most critical season for livestock in the Sahel. This study aims to monitor the spatiotemporal variation of forage quality for the herbaceous stratum in Senegalese rangelands. To this end, near-infrared spectroscopy (NIRS) analyses were made to obtain predictions of fibers (ADF and NDF) and nitrogenous (MAT) contain (%) from forage samples collected in 2021 at 11 sites across the Senegalese silvopastoral zone. Multilinear models were calibrated with Sentinel-2 spectral indices to estimate these quality parameters across the study area. The results showed an accurate estimate of quality

variables with a R² of 0.70 for MAT, 0.81 for ADF and 0.48 for NDF. A constant trend of MAT was observed during the dry season against a slightly increasing trend for ADF and NDF. The forage quality changes according to ecoregions (higher MAT in northern sandy region with 4% and higher ADF and NDF in the transition zone with 60% and 85%, respectively) and rainfall zones (the more arid is the area, the less is the ADF and NDF with an average value of 53% and 75%, respectively, where rainfall ≤ 300mm. The opposite effect was observed for MAT). These findings showed that sentinel-2 images combined with NIRS predictions is a promising tool for the assessment of forage quality, necessary for more timely forage and livestock management in the Sahel.

Keywords: dry season quality forage, NIRS, Sentinel-2, statistical modeling, sustainability Senegalese forage resources

Monitoring Rewilding Landscapes with Uncrewed Aircraft Systems: A Protocol Employing Object-Based Image Analysis and Machine Learning to Estimate Landscape Heterogeneity Metrics

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Vegetation heterogeneity at the landscape level is a crucial indicator for monitoring the success of rewilding efforts in Europe. Baseline mapping and estimating heterogeneity metrics must follow accurate, efficient and repeatable methods. The critical workflow elements in achieving these goals are appropriate data acquisition and parameterisation, fit-for-the-purpose technologies and robust algorithms for big data processing and analyses. Six 5-ha plots in the Greater Coa Valley in Portugal were used as a pilot for testing a combination of methods and technologies. Due to the magnitude and scale of the expected changes, ultra-high-resolution images were considered the most appropriate data for such analyses. Uncrewed Aircraft Systems (UAS), i.e. aerial vehicles, multispectral sensors and a ground station, were employed for image acquisition. Structure from Motion (SfM) processing led to orthomosaic imagery, vegetation indices and vegetation height in resolutions of approximately 5cm and 10cm from RGB and multispectral (MSS) data, respectively. Due to the reflectance variability of vegetation in these resolutions, object-based image analysis (OBIA) was preferred over pixel-based approaches. Supervised classification of objects in seven dominant life-form vegetation classes was done in eCognition using the Random Forest algorithm. Integration of tri-seasonal RGB images was compared with single-season MSS data. Classification accuracy was 93% and 85%, respectively. A notable difference between the two approaches is that MSS data can be obtained in a single field campaign. Outputs from classification were used in quantifying relevant landscape metrics such as edge density, shape index, patch number density and richness, and Shannon's Diversity Index in FRAGSTATS software. The results of the proposed methods in the pilot study in Coa Valley were satisfactory, appropriate and straightforward at the operational level. The pilot study in Coa Valley offered valuable confirmation of the applicability and refinements to be used further in the European rewilding areas in the near future.

How Effective the Mangrove Restoration Programs are in Sequestrating Carbon? Evidences from Eastern India through Integration of Geospatial Technologies and In-Situ Measurements

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Coastal ecosystems sequestrate more carbon (C) per unit area than other ecosystems but amplified anthropogenic disturbances and degradations in the Anthropocene have rendered a serious threat to their vitality. This study assesses the effectiveness of a mangrove restoration program of eastern India, namely Bichitrapur sanctuary, through the analysis of land use/ land cover (LULC) dynamics (2000-2020) and makes a spatially explicit estimation of its total blue C (TBC) stock and carbon credit. It also aims for probable synchronization of the empirical findings with the socio-ecological objectives of the restoration program. Here, LULC dynamics were investigated using Landsat TM and Pleiades-1A datasets. The TBC stock was appraised by integration of multisensory geospatial datasets, in-situ destructive and non-destructive samplings, allometric relationships and machine learning algorithm. Among different blue C components, soil organic C (SOC) was modelled by spatial interpolation of point-specific SOC density dataset. Above ground biomass (AGB) was computed using allometric relationships between remotely sensed data and in-situ dendometric parameters. The below ground biomass (BGB) was estimated using allometric associations with the modelled AGB. The TBC stock was appraised through aggregation of these blue C component values and thereby transformed into carbon credit. Results revealed a trend of areal decrease for mixed vegetation and waterbody categories; while dense mangrove, open mangrove, and aquaculture experienced increasing trends. Spline interpolation (R2 = 0.74) and artificial neural network (adjusted R2 = 0.84) were inferred to be the best fit models for SOC and AGB estimations, respectively. The TBC stock of the site was projected as 2,46,710.91 Mg, which was comparable to 9,05,429.04 units of carbon credit. Precisely, this study may be reckoned as a pioneering one regarding spatially explicit TBC accounting and facilitation of valuable inputs for improving regional and national C inventories of India through ecosystem restoration and conservation.

Keywords: Allometric relationship, Carbon credit, Restored mangrove, Spatially explicit modelling, Total blue carbon.

Climate-Regulating Services of Forest Landscapes: Geostatistical Modeling Based on Remote Sensing

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Remote sensing provides an instrumental measurement of the biophysical parameters of the vegetation cover: components of the energy balance and structural-information measures that characterize the organization of a system that converts solar energy. Relationships

between biophysical variables and parameters of the climate system (temperatures and precipitation, radiation, etc.) are considered by us as ecosystem services, as the work of vegetation to maintain the climate. Having already quite long series of satellite measurements, we are able to identify various components of the dynamics of biophysical variables: the stationary (invariant) part, trends and deviations. Thus, we have the opportunity to assess the dynamics of the climate control service. In this report, we present the results of the analysis of spatio-temporal variation of biophysical and climatic parameters and climate-regulating services as their functions on the example of a part of the territory of European Russia. Also, the estimates obtained make it possible to assess the balance of the existing landscape structure and land use structure in terms of climatic and biophysical parameters, and thereby identify the most vulnerable areas for climate change. The analysis showed that the minimally anthropogenized types of landscape cover have the maximum ability to regulate the climate. The maximum climate-regulating function is manifested for summer temperatures and winter precipitation. The values of biophysical parameters make the greatest contribution to the regulation of temperatures in light forests, mainly in the tundra, in the zone of mixed forests and in the steppe zone. Autumn precipitation is associated to the maximum extent with biophysical parameters in steppe landscapes.

Understanding Current and Future Risks of Biodiversity Loss Through the Analysis of Land Use Land Cover Change and Climatic Variables in South Africa

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Biodiversity provides a variety of ecosystem goods and services that are crucial to human well-being. Global environmental change, which includes climate and land use land cover change (LULCC) is attributed to the rapid rate of biodiversity loss at a species and habitat level. These changes led to the transformation of approximately 50% of the earth's land surface, affecting biodiversity and ecological processes. Here, biodiversity loss is defined as a conversion from natural to non-natural classes. The question is, does the risk of biodiversity loss mediated by climate change or not at a national scale? The National land cover change products (SANLC) between 1990 and 2018 were derived from multi-seasonal Landsat and Sentinel-2 images at 30m and 20m spatial resolution, respectively. The biodiversity loss data was associated with climate variables such as anomalies, coefficient of variations (CV) for various seasons, fire index, flood days and water vapour pressure for the period of 1971 – 2000 (baseline), 2000-2020 (current), 2020-2025, 2025-2030 (future). An

ensemble of machine learning techniques was used to develop optimal models for estimating and mapping the risk of biodiversity loss mediated by climate variables. Savannah and the grassland biomes experienced the most biodiversity loss currently and the future risk is also significant in those two biomes. The loss of biodiversity in the fynbos and Indian coastal belt is also high relative to their sizes. About 3 and 4.5 per cent of habitat was lost between 1990 and 2018 in the fynbos and the Indian coastal belt biomes, respectively. The risk of loss based on climatic variability is significant in the latter biomes, including the savanna and grasslands. Climate variables explained 69% of the variation of biodiversity loss risk (AUC = 0.69). Future biodiversity loss risks are noted in the same biomes. The results of this study are important for planning and prioritizing areas to prevent, reverse or restore ecosystems, and to safeguard biodiversity not only for future expansions of protected areas but to support livelihoods.

Keywords: biodiversity loss, climate change, land use land cover, remote sensing, climate data

Time Series Analysis of Satellite Data for Early Detection of Changes in Ecosystems in Tanzania

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Traditionally, changes in land cover are used for the assessment of alternations in the ecosystems. Although such approach is very popular land cover changes reflect only very evident variations in the environment, usually caused by humans. A natural evolution of ecosystems, e.g., related to the climate change, is relatively slow and does not appear directly in land cover status. This process can be reflected in changes in functioning of ecosystems or in their biomass. Satellite remote sensing delivers a huge amount of data, which allows regular observations of the environment. This work presents a method for satellite monitoring for early detection of changes. We use time series of optical and radar Sentinel images to map Ecosystem Functional Types (EFT) in west northern Tanzania for years 2016-2022. We modified the EFT concept to analyse not only photosynthetical activity of vegetation, but also changes in its water content and biomass. Basing on four-dimensional analysis of vegetation (time, photosynthesis, moisture and biomass) we establish areas, which are under a stress and undergo changes. We compare our results with the traditional land cover maps elaborated year by year for the study period to show how fast we detect the first symptoms of the alternation in ecosystems before it results in land cover change.

Immediate And Long-Term Effects of Severe Wind Disturbance on Structure and Carbon Storage Capacity of on Puerto Rican Forests

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Beyond its effects on temperature and precipitation, climate change is projected to alter disturbance regimes. The frequency and/or intensity of several types of disturbances, including cyclonic storms, fires, and floods, are anticipated to rise with climate change. Predicting the effects of these changes on ecosystems is one key challenge for global change research. Cyclonic storms (hurricanes, cyclones, and typhoons) represent the dominant natural disturbance in many coastal tropical forests. Projected increases in cyclonic storm intensity under a warming climate will have profound effects on forests, potentially changing these ecosystems from carbon sinks to sources. Forecasting storm impacts on these ecosystems requires consideration of risk factors associated with storm meteorology, landscape structure, and forest attributes. We evaluated risk factors associated with short-term damage severity caused by Hurricane María (category 4) on Puerto Rican forests. Using field and remote sensing data, total forest aboveground biomass (AGB) lost to the storms was estimated at 10.44 (±2.33) Tg, ca. 23% of island-wide pre-hurricane forest AGB. However, an island-wide analysis of the drivers of forest height and structure found no long-term effects of exposure to two previous hurricanes (category 3), H. Hugo in 1989 and H. Georges in 1998, found no effects of the storms. Instead, long-term exposure to chronic winds and land use legacies explained variation in forest height and structure across the island. Our results demonstrate that severe cyclonic storms have substantial short-term effects on forest structure and carbon storage. However, forest age and chronic wind-exposure shape the structure and carbon storage of tropical forests over longer time scales.

To Restore Biodiversity and Urban Ecosystem Through Integrating Ecological Landscape Design: The Case of Declining Fireflies Species in The City of Delhi

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In developing countries like India, rapid urbanization, industrialization, and poor planning have created profound altercations to the natural environment over the past decades. Delhi being a major metropolitan city and the capital of India, degradation of the urban ecosystem is responsible for bringing a drastic change of the urban biodiversity resulting in loss of flora and fauna population. Fireflies are one such species that are under global threat due to habitat loss and fragmentation, light and water pollution, use of pesticides, intensification of agriculture and absence of native planting and natural landscape where researchers have concluded that some 2000 firefly species in the world may face extinction in coming years. The declining number of firefly is a cause of concern among ecologists as it points to deteriorating ecosystem which is unable to sustain the insect population.Fireflies are glowworms and iconic celebrated insects whose fascinating bioluminescent displays have unique cultural, biological, economic, and important components of natural biome which keep the ecosystem in a delicate balance and make an ideal bioindicator. In the city, their ecological habitat has

critically reduced to low abundance of species diversity. Therefore, it becomes imperative to restore, protect and enhance the firefly habitat mosaic through ecological landscape design based on the principles of landscape ecology and human values to create biodiverse landscapes to achieve overall ecological sustainability in the urban fabric.The aim of the paper is to outline the importance of fireflies and threats to their decline and collect baseline data and distribution on firefly populations. To understand the character of environment, behavior and physiological aspects required for their ecosystem through their complete lifecycle creating a framework of design modules, policies and raise awareness to produce improved and enhanced urban ecosystem with a possibility to a new experience in the form of an ecotourism.

Keywords: Ecological Landscape Design, Landscape Ecology, Urban Biodiversity, Urban Ecosystem, Ecological Sustainability

Deep Learning and Radiative Transfer Model Integration with Sentinel-2 To Improve Characterization of An Invasive Alien Plant Across Complex Landscapes

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Deep learning has emerged as a powerful algorithm in numerous applications over the past decade. It is, however, underutilized in remote sensing applications, particularly for predicting plant biophysical variables in South Africa's heterogeneous environment. This kernel-based machine learning technique is more accurate and reliable than traditional methods for estimating remotely sensed vegetation characteristics. In this work, an attempt has been made to test the ability of deep learning algorithms to predict plant traits canopy chlorophyll content (CCC), and leaf area index (LAI) of IAP and co-occurring native plants using the Sentinel-2 surface reflectance imagery. Further, the study compared a radiative transfer model (RTM) inversion by deep learning algorithms trained on an RTM simulated dataset and S2 surface reflectance to predicting the plant traits useful for characterising invasive alien plants across montane grasslands in South Africa. The retrieval methods for predicting plant characteristics using both synthetic and Sentinel-2 spectral data were evaluated using in situ measurements from montane grasslands. The RTM inversion using synthetic dataset resulted in estimations of CCC ($R2 = 0.65$, RMSE = 0.33 g/m2), and LAI ($R2 = 0.82$, RMSE = 0.28 m2/m2), comparable to the estimations based on the S2 surface reflectance regression model of CCC ($R2 = 0.68$, RMSE = 0.41g/m2), and LAI ($R2 = 0.87$, RMSE = 0.25 m2/m2). Deep learning yielded accuracies and robustness with synthetic reflectance similar to the RTM inversion using S2 surface reflectance dataset. The performance of regression methods trained on synthetic datasets showed promise for the rapid and accurate mapping of IAPs and co-occurring native plant traits across montane grasslands in South Africa using data obtained from remote sensing.

Keyword: Machine learning, Deep learning, canopy chlorophyll content, Convolutional Neural Network, leaf area index, Sentinel-2

Dendroclimatic Response of a Multispecies Chronology in the Wet Miombo Woodland of Zambia

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Zambia is a tropical landlocked country that lies in the South-Central part of Africa. Its climate features distinct dry and rainy seasons. This is mainly influenced by the north and south movement of the Inter Tropical Convergence Zone (ITCZ) which shifts seasonally. According to ZamStats 2022 report, the population of Zambia is now over 19,600 million, meaning more forest reserves will be cleared for human settlements. This research focuses on understanding the role of trees in the ecosystem and how climate change affects forest density. From the available chronologies in the International Tree Ring DataBank (ITRDB), Africa remains the least sampled continent when it comes to dendrochronological study (use of tree rings to understand past climate and vegetation) hence the need to feel this gap. A forest owned by African Explosives Limited (AEL) was chosen as the study site because it is undisturbed. It lies 15 km South of Mufulira, Zambia. We have collected tree cores samples of 32 tropical species, among them Julbernadia paniculata, Brachystegia longifolia, and Pericopsis angolensis. This will be the first dendroclimatic evaluation of some of the mentioned species, which will provide valuable information about the climatic factors that limit growth of deciduous trees in Zambia. We plan to build individual species chronologies from the ten most useful species and look at the relationship of tree growth to climate and later share these findings with ITRDB. We used Multiple Variable Area Transect for our sampling methodology and found that P. angolensis had the highest number of trees per hectare, followed by B. longifolia. We constructed a standard multispecies chronology in R. Tree ring width response to climate was also reported and current February and August precipitation showed a strong correlation to tree growth. Previous January temperature also showed a strong correlation to tree growth.

Historical Analysis of Land Use and Land Cover Change for Better Informed Forest Landscape Restoration Implementation: Case Study of Tchamba Prefecture (Togo)

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Land use and land cover change (LULC) remained major concern in many countries. Although studies have been carried out to raise awareness of LULC issues, forest landscape restoration (FLR) projects are launched without prior land-use investigation. To examine LULC to support implementation of FRL actions, remote sensing is used to analyse 31-year multitemporal LULC changes while future patterns for the next three decades were predicted using the Cellular Automata-Markov modelling technique in Tchamba prefecture. As results, in 1991, forest cover represented almost 90 % of the area with tree and shrub savannah being the

predominant class. However, most tree and shrub savannah were meanly converted to dense forests and gallery forests, open forest and woodland, plantations, mosaic crops and fallow land. Contrary to the fast disappearance of tree and shrub savannah, dense forests and gallery forests have experienced little degradation while mosaic crop and fallow land, and plantations expanded at more than 7%. Modelling results showed that by 2050, open forest and woodland as Tree and shrub savannahs will decrease, while there will be increases in dense forests and gallery forests, in plantations, in mosaic crops and fallow land, and built-up. The little decrease of dense forests and gallery forests and the increase of plantations are largely attributed to the policy awareness, the local management in conserving community natural forests, and the intensification of reforestation, including endogenous and resilient agroforestry practices. It is therefore necessary for all actors to consider these information's when planning activities related to FLR.

Keywords: Remote Sensing; Land Use Change; Forest Landscape Restoration

GLOBAL GLOBAL CHANGE AND THE DYNAMICS OF AFRICAN

Recent Trends of Increasing Fire Activity in African Tropical Forests

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The majority of global wildfire activity occurs in the savanna and woodland ecosystems of Africa. In contrast, fires have historically been rare in the tropical forests of West and Central Africa, where the vegetation structure, high decomposition rates, and high moisture levels limit available fuels. However, because of global change, the African tropics are becoming increasingly susceptible to wildfires. Increasing temperatures and the occurrence of droughts reduce fuel moisture and make forests more vulnerable to burning. Growing human populations have increased logging and land use conversion for agriculture. These human activities provide more ignition sources and cause forest degradation and fragmentation that increase susceptibility to wildfire spread. We used satellite remote sensing to evaluate recent fire trends in African tropical forests and examined their associations with patterns of precipitation and deforestation.Data sources included the MODIS active fire and burned area products from 2003-2021 and the VIIRS active fire product from 2013-2021. Annual summaries for each fire variable were derived for 0.05-degree grid cells, and trend analyses were carried out for each dataset using the Mann-Kendall test. In the tropical forest ecoregions, positive trends in fire occurrence were much more common than negative trends. The largest concentrations of positive trends occurred in the northeastern Congo Basin and along its southern edge. Across most of Africa, trends of increasing fire generally occurred in areas with increasing deforestation. In some locations, increasing fires were also associated with decreasing precipitation, but these relationships were more spatially variable.

Increasing fire frequency and burned area in tropical forests can trigger positive feedback loops in which the resulting degradation increases susceptibility to future fires. Further research is needed in these hotspots to identify specific local risk factors, develop applications for fire risk forecasting, and implement strategies for forest protection and restoration.

Spaceborne Remote Sensing of African Tropical Forest Productivity and Drivers

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The intra- and inter-annual variability of global atmospheric carbon dioxide concentrations is largely driven by changes in the terrestrial uptake of carbon dioxide through photosynthesis. Tropical forests account for about one third of global terrestrial photosynthesis, but relatively less is known about the seasonality and drivers of tropical forest productivity in African landscapes due to a lack of eddy covariance and airborne XCO2 data.

In an effort to help fill this knowledge gap, we used (1) Level 2 spaceborne solar-induced chlorophyll fluorescence (SIF) from OCO-2, OCO-3, and TROPOMI; (2) MODIS- and VIIRS-based vegetation indices (EVI, NIRv, NDVI, and LSWI); and (3) CHIRPS precipitation to investigate the seasonality and drivers of tropical forest

productivity in 12 of Africa's tropical forest ecoregions. We found that SIF was significantly correlated with precipitation across all ecoregions, but that the strength of the correlation was higher for ecoregions with less total annual rainfall. We did not observe this phenomenon with the vegetation indices. Lag correlations between SIF and precipitation indicated that SIF and precipitation was less coupled in the wetter ecoregions. We also found that SIF was overall more strongly correlated with precipitation than the vegetation indices, and that the distinctive double-peak seasonality of fluorescence, which we observed in most ecoregions, was either muted or not found in the seasonality of the vegetation indices. Further work is needed to establish whether the seasonality of SIF for each ecoregion is robust across sun-sensor geometries and observations of various cloud-fraction thresholds. Analyses and comparisons of commonly used GPP products and SIF would also provide more insight into the degree to which these data sources agree and constrain our knowledge of the timing and magnitude of the uptake of atmospheric carbon dioxide by in African tropical forests landscapes.

Estimating Above Ground Biomass and Carbon Stocks of the Budongo Tropical Rainforest Using Polarimetric Synthetic Aperture Radar (SAR) Interferometry

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Estimation of biomass is an important means for understanding the dynamics of a forest ecosystem and the effect of forest disturbances on productivity and carbon storage of forest stands. In the recent years, there has been a growing interest in the possibility of using remote sensing to estimate carbon stocks in terrestrial systems such as tropical rainforests. Radar remote sensing is being adopted as a popular method for estimating above ground biomass over large areas because of its ability to penetrate through cloud cover and the forest canopy. There has been no regularized attempt to assess the carbon stocks for the Budongo Forest despite its importance in the national ecosystem. Research on carbon storage and absorption capability of the forest is thus very vital, to help in formulating emission reduction strategies for sustainable development. This study seeks to use Polarimetric Synthetic Aperture Radar Interferometry to estimate Carbon stocks over the Budongo Tropical rainforest. The technique has been adopted to reduce signal saturation, which is a major limitation in SAR remote sensing systems for higher biomass levels, to allow for a detailed characterization of Carbon stocks. Radar images of the study area are decomposed into higher order scattering mechanisms through polarimetric phase analysis. Thereafter, forest heights are derived by intereformetric differencing of two images of a scene acquired at different times. Field allometric measurements are used for training and validation. Above ground biomass and Carbon Stocks are then estimated through inversion and regression analysis. The model is still under development but preliminary results indicate a Carbon Stock estimate of 265.5 Mg/ha C for the forest. Final results to be ready by May, 2023.

Assessing the Spatial Variability of Bracken Fern During Dormancy Phenological Stage Using Planetscope and Object-Based Image Analysis

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The spread of invasive alien plants such as bracken fern is now internationally recognized as one of the most serious threats to biodiversity globally. Through image analysis, remote sensing provides an efficient tool to map the spatial distribution and variability of bracken fern at different phenological stages. Pixel-based classification approaches have been widely used in the remote sensing of bracken fern. However, pixel-based image analysis approaches are associated with the "salt and pepper effect", which is normally caused by sharp and sudden disturbances in the image signal. The current study aimed at assessing the spatial variability of bracken fern during dormancy phenological stage using PlanetScope data and object-based image analysis. The study also aimed at developing an autonomous google earth engine web-based application for monitoring the spatial variability of the fern during the dormancy phenological stage. The spatial variability patterns of bracken fern across the landscape and its relationship to topographic variables was also examined. The Simple Non-Iterative Clustering (SNIC) was used to identify the spatial clusters while the Gray-Level Co-occurrence Matrix (GLCM) was employed to compute textural indices on a cluster basis. The results indicate that senesced and remnant green bracken fern exhibit similar spectral reflectance properties, leading to spectral confusion between the two. The study also found that the degree of spectral confusion varies with environmental factors such as topography and soil moisture. The results show that the object-based classification approach which included bracken fern texture information yielded the highest overall accuracy (93.6%). The major topographic variables influencing the spatial variability of bracken fern during the dormancy phenological stage were elevation, Topographic Wetness Index (TWI), valley depth and positive openness. This study contributes to the understanding of the ecology of bracken fern and provides useful information for the management of bracken fern alien invasive species in rangelands.

Patterns And Drivers of Recent Disturbance in Tropical Forest Reserves of Southwestern Ghana
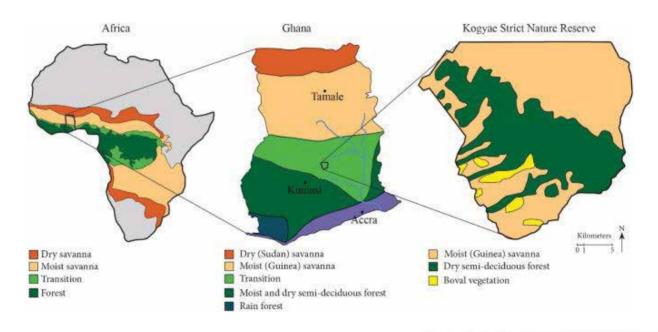
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Ghana has retained a substantial area of tropical forests in an extensive network of protected reserves. These forests are impacted by land uses such as logging, mining, and agriculture as well as wildfires. We studied forest disturbance and recovery from 2013 to 2020 using annual maps of forest cover derived from Landsat imagery. Fire-associated disturbance was distinguished using VIIRS active fire data. We used boosted regression trees to model disturbances in closed and open forests

as a function of climate variability, human accessibility, and landscape structure. A total of 3,562 km2 of forest reserves were disturbed, of which 17% (615 km2) were fire disturbances and 83% (2,946 km2) were non-fire disturbances. Of the total disturbed area, 68% was degradation (change from closed to open forest), 28% was open forest loss, and only 4% was closed forest loss. Over the same period, 2,702 km2 of forest reserves recovered, with 1,948 km2 of these recovering to closed-canopy forests. Fire disturbances were strongly associated with precipitation anomalies and occurred mostly in drier years, whereas non-fire disturbances had weaker relationships with precipitation. Disturbances in closed forests occurred in landscapes where closed forest cover was already low. In contrast, disturbances in open forests were most common in locations with intermediate levels of population pressure from nearby cities and proximity to non-forest land cover. The results support the idea that forest disturbance in Ghana is a multi-stage process involving degradation of closed forests followed by loss of the resulting open forests. Although non-fire disturbance rates are consistent from year to year, sharp increases in fire disturbance occur in drought years. Locations with the highest disturbance risk are associated with measurable indicators of climate, human pressure, and fragmentation, which can be used to identify these areas for conservation and forest restoration activities.

Green Infrastructure for Climate Regulation of UrbanEnvironments: Policies, Plans and Models

Investigating Public Perception Towards Urban Forest Planning and Institutional Involvement on the Copperbelt Province, Zambia.

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Urban environmental issues such as urban heat, flooding and pollution have become common in urban areas which has led to changes to the urban form. Urban forestry is the planting, care and management of trees in urban areas aimed at bettering the urban environment and human wellbeing. Thus, environmental issues coupled with population increate and climate change has led to the concept of urban forestry becoming a global phenomenon. Trees have been recognized as a major pathway toward city livability and sustainability because they reduce the extreme temperatures and regulate storm water runoff, thereby bettering the environmental conditions of urban areas.The increase in the tree cover loss and unclear public perception towards urban forestry and the extent to which stakeholders are involved in urban forestry development formed the basis for this study. The study employed a mixed method approach and a total of 400 households were randomly selected and 12 interview sessions with experts from purposively selected institutions in the target districts were conducted. The data was cleaned in excel and analyzed using SPSS software. The results showed that there is a positive public perception towards urban forestry with 93% of the respondents having trees planted at their properties. 58% of the institutions surveyed were fully involved in urban forestry activities in different capacities. Besides, plantation activities (52%) and awareness raising programs (35%) were suggested as key towards urban forestry development. Hence, it's been concluded that people are willing to support and participate in urban forestry activities except many are ignorant about the benefits. Thus, incorporating the concept of urban forestry in the school curriculum, door to door sensitization and Media shows are key forms of awareness raising.

Key Words: Urban Forestry, Public Perception and Institutional Involvement.

Investigating the Spatial Distribution of Urban Forests and Urban Heat in Mid- and Large-Sized Cities in Ontario, Canada from an Environmental Justice Perspective

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Urban forests are increasingly being incorporated into planning and design of cities worldwide, because of their numerous benefits (i.e., ecosystem services), which are vital for human well-being, economic prosperity, and environmental sustainability. However, evidence

from around the world oftentimes suggests that access to urban forests is not equitably afforded to all population groups, raising an environmental justice issue. However, while most prior studies have focused on large and mega-cities, less evidence is available for small- and mid-sized cities. To address this gap, we conducted a study on the cooling effect of urban forests as an important ecosystem service and investigated the relationships between spatial distribution of urban forests, land surface temperature and key socioeconomic and sociodemographic variables across twelve mostly mid-sized cities in Southern Ontario, Canada. We used satellite imagery to map urban forests and land surface temperature, and obtained socioeconomic and sociodemographic data from the national Canadian population census. We then used aspatial methods, such as Gini coefficient, and spatial methods, such as geographically-weighted regression to assess relationships and patterns of segregation. While we generally detected unequitable distribution of urban forests and high temperatures such that low-income and ethnic-minority groups had less access to urban forests and resided in hotter surroundings. However, we also observed noticeable variation across cities. We discuss the implications of our findings for the theory and practice of urban planning and believe that our results produce transferrable insights, which can inform policies striving to create more liveable, resilient, and equitable cities.

Keywords: *Urban Forest; urban heat island; ecosystem service; environmental justice; remote sensing*

Lower Canopy Cover, Greater Cooling Efficiency of Urban Trees? A Continental Cross-City Comparison

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Increasing urban tree canopy (UTC) has been widely recognized as an effective nature-based solution for extreme urban heat mitigation. Numerous studies have shown that the cooling efficiency (CE) of urban trees varies by cities with different climate backgrounds, and recent research further indicates that there may be large within-city variations in cooling efficiency. However, whether there is a generalizable pattern of such within-city variations, and how it relates to the amount of UTC remains poorly understood. This study aims to fill this gap through investigating the within-city variation of CE and its relationship with the percent cover of UTC (Ptree) across 118 cities with different biomes and climates in the continental USA. We found: 1) CE had high within-city spatial heterogeneity, and such heterogeneity varied among cities. CE had larger within-city and cross-city spatial variations in cities located in dry biomes. 2) CE was related to Ptree in nonlinear ways in more than 90% of the study cities. In most cities, CE had an L-shaped relationship with Ptree, showing that CE first declined quickly with the increase of Ptree, but then

dropped in a slower way, and gradually became relatively stable after Ptree reached a certain threshold. Other three types of nonlinear relationship included J-shaped, inverted L-shaped, and N-shaped. There was one city having a negative linear relationship. 3) While there was no significant difference in the types of relationship between CE and Ptree among biomes and climates, the turning point of Ptree at which the relationship changed was different, showing smaller values in cities with dry biomes and climates. The results enhance our understanding on the within-city spatial heterogeneity of the cooling effect of urban trees and its relationship to UTC coverage, which can provide insights on prioritizing locations for urban tree planting for to achieve greater cooling benefits.

Keywords: Cooling efficiency; Urban tree canopy; Spatial heterogeneity; Geographically Weighted Regression; Piecewise regression.

Comparing Relationships Between Urban Heat Exposure, Ecological Structure, and Socio-Economic Patterns in Beijing and New York City

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Managing and adapting to extreme heat in cities has become increasingly important as climate change and the urban heat island (UHI) effects jointly exacerbate the risk of heat-related mortality. Many studies have been conducted to assess heat risk based on socioeconomic factors, or to quantify spatial patterns of urban greenspace due to its cooling effects. Few studies, however, have examined the relationship among urban ecosystem structure, urban heat exposure, and socio-economic patterns of vulnerability to heat. Here, we took a comprehensive approach to assess current heat related exposure within cities to reveal how optimizing spatial patterns of urban greenspace can improve the cooling efficiency. We present a comparison study of two megacities—Beijing, China and New York City (NYC), USA to examine how such relationships differ in different urban contexts. We found different social vulnerability patterns in the two cities, with high heat risk in Beijing occurring in areas with high population density and elderly, while in NYC, heat risk was the highest in areas with high density of people living below poverty. Meanwhile, the areas with higher social vulnerability had less green cover. In addition to increasing percentage of greenspace, we found the quality of urban greenspace was more important than its spatial configuration in mitigating urban heat in Beijing, but the shape of green patches played the most important role in alleviating heat risk in NYC. The spatial distribution of social-economic and ecological factors jointly led to inequities in exposure to urban heat. These results indicated that targeted adaptation and mitigation measures that prioritize urban greenspace in the most socially vulnerable locations and improve cooling capacity of existing green patches are necessary for heat risk reduction and improved equity.

High-Resolution Urban Mapping for Enhanced Urban Planning and Management - A Case Study for Aarhus, Denmark

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To foster urban resilience and adaptation to climate change, knowledge of land use and land cover (LULC) is needed for urban landscapes. High-resolution urban mapping is a valuable tool that maps detailed categories, and its semantic data can be integrated into national, regional and local administration. Here, we present a threshold-driven method to map urban areas and extract vegetation information automatically from multitemporal orthophotos and LiDAR data. Municipal datasets are included to add additional land-use as well as ownership information. The results provide a detailed LULC map for Aarhus in 2015 with ten thematic classes and a sub-meter spatial resolution. This methodology can be applied to other areas at national level, e.g.in Denmark, or to countries with similar datasets. For monitoring purposes, it can be repeated with minimal user interaction. Our evaluation focuses on the distribution of green infrastructure, sealed surfaces, and vegetation in public and private spaces, agricultural lands, and industrial and commercial sites in Aarhus. It is thus valuable resource for urban planning and management. The distribution of green infrastructure and sealed surfaces in Aarhus provides insight into areas for which different planning departments have contrary ambitions: either they require the area for further development or towards intensifying conservation efforts. The information on vegetation distribution and land use thus aids in decision-making processes related to urban growth, environmental conservation, and risk management. This is especially important, as Aarhus names flooding as one of the major risks. Our study also highlights the potential of high-resolution urban mapping as a tool for other geohazards in cities, or for monitoring changes in urban areas over time. By providing accurate and detailed information on LULC, this approach unveils conflicting planning projects in economically versus ecologically priority areas. It may also examine its potential by integrating socio-economic data to enhance urban planning and management.

High Resolution Urban Greening Scenarios for Climate Regulation

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Urban Ecosystems represent the main providers of ecosystem services in cities and play a relevant role, among the many services, in the regulation of the urban microclimate and mitigation of Urban Heat Island effect. The amount, localization and spatial configuration of vegetation (i.e., urban trees) are key factors for planners and designers aiming at maximizing the climate regulation potential and therefore extending the related benefits to the higher number of residents and city users. Different factors and constraints determine the

potential of the cooling effects of vegetation and the way these effects can actually benefits both the elements of urban environment (i.e., streets, sidewalks, squares, parks) and people that makes a daily use of these elements. This paper investigates on these factors by identifying high resolution scenarios of new urban greenery that are able to maximise the cooling benefits for people and local residents. For the case study of Mediterranean metropolitan areas of Catania (Italy), scenarios are derived by modelling physical and socio-economical factors as spatial constraints for the localization of new urban vegetation, with the UMEP model and GIS spatial analysis. Results show that new greenery should be located in public areas that are mostly used. Built on results obtained in the case study analysed, the paper also proposes some general planning criteria for the localization of new urban greenery, to be extended to other geographical urban contexts.

A Collaborative Approach to Green Infrastructure Planning in Sub-Saharan Africa

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The systematic integration of green infrastructure concepts in urban planning is an essential approach to tackle significant current and future challenges. Cities in sub-Saharan Africa face rapid urbanization and struggle to address the depletion and degradation of existing GI that increases their vulnerability to climatic hazards. This paper reports on the findings of a multidisciplinary research project that investigated green infrastructure planning in the City of Tshwane, South Africa over two years. We drew on 200 community surveys, reviewed 28 policy documents, and conducted 18 semi-structured interviews with metro officials, four design studios and eight co-creation workshops that explored GI spatial planning and design in the city. We investigated the uptake of GI planning principles, the challenges, opportunities and local proposals for GI applications, and here synthesize some main conclusions. We found opportunities to create socioeconomic incentives for positive human-nature relations and care for GI in local communities across genders and generations. Interactive, creative research can facilitate increased local awareness and engagement, but access to benefits is socially determined by factors such as knowledge, gender relations, and safety. Based on the former we propose five local GI planning principles to protect the environment by using it, to create opportunities for GI access and co-ownership, to encourage multi-functional, safe and flexible GI, to support multiscale GI integration, and to strengthen collaborative governance with cross-sectoral partnerships. Rather than emphasizing the improvement of conventional GI planning measures, we advocate the need for flexibility and creative alternatives in context.

Keywords: Design; Global South; green space; planning principles; urban; South Africa

Urban Regions in the Anthropocene: Challenges and Perspectives, Milan (Italy) of Integrated Green Infrastructures as Case Study

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Urbanization represents one of the main characteristics of the Anthropocene, and the challenges it poses require responses also in landscape ecology. Milan and Bangalore, two cities comparable in economic characteristics are a good case study. The network of urban parks, the management of trees and water, makes it possible to propose options that together provide a functional green infrastructure and that lead to an increase in ecosystem services. For the urban region of Milan, we propose a vision, in which the urban matrix of the Milan region is redeveloped through different interventions. The overall frame is the diffuse corridor model. Then, within it, restoration projects were carried out for individual humid biotopes and entire river branches (involving numerous municipalities). Inside the denser urban area, a study on the parks and on urban forests propose a way of tree management that increase the benefit for bird population and the overall levels of biodiversity. Furthermore, taking in account and evaluating the ecosystem services provided by urban parks may increase the awareness of the need of a vision of green infrastructures. Studies on ecosystem services have then made it possible to show the important role that green infrastructures have in improving the quality of life and in achieving sustainable development goals.

Building Performance Simulation for Sustainable Urban Planning

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Building Performance Simulation (BPS) is an area of building science dedicated to the calculation and prediction of buildings-environment interaction, including energy flows, lightening, acoustics, thermal comfort, and other human-related concerns of built environments. Sustainable Urban Planning (SUP) is a discipline promoting urban structure analysis contributing to the development of human activities in a sustainable way. Among SUP strategies we can account for city greening, urban form modification, urban materials, transportation, blue infrastructure, ventilation, and other environmental topics in urbanized land. Recently, BPS has been proposed as fundamental part of a general methodology to estimate energy benefits that can be obtained through the implementation of a green infrastructure in cooling-dominated climates. In this work, the combination of BPS and machine learning (ML) strategies to predict and classify urban greening scenarios in different climates is presented. Results show that BPS and ML are methods that can be easily coupled or combined in chain, and that such a combination is useful to urban and environmental planners to establish how to design green infrastructures (or other interventions) in order to maximize energy benefits.

Climate Change, Health, and Urban Planning: A Challenge for Developing Countries.

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Climate change is pushing mankind to the planetary boundaries. Several critical processes have been intensified overpassing the reasonable limits established to control the equilibrium of the Earth. Land use change, pollution, water management are some of most important urban-related processes that should be controlled, because of the direct impact on human well-being and, in some cases, even on habitability and capacity to survive in such environments. This work presents the relationship among climate change, urban heat island and human health in South America. Built environment is analysed as a potential source of illnesses and morbidities associated with global temperature increase. Some mitigation and adaptation policies are proposed for the actualization of buildings codes, considering the warming world scenarios that will change energy needs and thermal performance of buildings and cities.

Green Facades and Green Roofs for the Reduction of Urban Heat Island in Mediterranean Cities of Chile

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The urbanization of natural landscape implies modifications of the spatial conformation, in urban morphology, surface materials, etc. giving rise to the urban climate, whose main characteristic is the positive temperature difference with the rural environment: a phenomenon known as Urban Heat. Island, which favors the increase in energy consumption in buildings, affects air quality and the well-being and health of the inhabitants. Due to extreme situations such as heat waves, climate change is expected to intensify UHI conditions. Ways to mitigate this effect are urgently sought. The objective of this research is to determine the impact caused by the implementation of green roofs and facades, on urban surface temperatures and air temperature at pedestrian level, in the cities of Valparaíso and Rancagua, located in a Mediterranean climate in the central zone of Chili. Satellite images and the ENVI- met software are used to determine the urban thermal behavior and the impact of implementation of green roofs and façades. A difference of up to 0.8°C is observed in the air temperature at the pedestrian level, between the scenario whose buildings do not have green coverage and one with 100% green coverage implemented. Regarding the green facades, a difference of up to 2°C is observed in the air temperature at the pedestrian level, between facades with 100% vegetation compared to one that does not have green facades. Green facades and green roofs have positive effects mitigating urban air heating and a decrease in temperatures inside the canyon, promoting greater thermal comfort for pedestrians.

Importance of Urban Green Spaces Conservation in Providing Ecosystem Services and Climate Change Mitigation in Developing Countries

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Urban green spaces (urban forests, urban parks, garden parks, sacred forests, roadside trees...) throughout their conservation play a high role in human well-being and welfare by mitigating climate effects. This is because of their capacity to exchange solar radiation from the sun that is transformed in CO_2 to freezing and fresh air fulfills of oxygen. These urban green spaces help with land conservation and stability and also with climate amelioration. Ecosystem services provided by urban green spaces are vital for humans in urban regions. Large and contiguous core nature areas, smaller green areas and ecological connections between them are the essence of regional ecological networks and are essential for maintaining interconnected habitats for species and thus biological diversity. Thus, both local and regional level ecological networks are vital for maintaining ecosystem services in urban regions. However, urban development through urbanization poses a great problem for the ability of urban green spaces to be conserved. The expansion of urban cities has resulted in the fragmentation of urban green spaces from rural green area. This phenomenon is still ongoing toward the cities. In that case, it is almost impossible for human to benefit of ecosystems services provided by urban green spaces. The impacts of climate change coupled with land-use and land cover change will bring serious challenges for maintaining urban green spaces and thus ecosystem services in urban areas. Indeed, despite its importance, urban green spaces faced a numerous pressure from those it protects. A numerous of people do not care about the benefit resulting of urban green spaces. This because there is a lack of information on ecosystem services of urban regions and there is a need to enhance the knowledge for cities development planning. The results of this project will help decision-makers and populations to take a good conservation strategy plan into the urbanization process with the purpose of climate adaptation and mitigation.

How Do We Incorporate Vegetation, Grazing and Landscape Heterogeneity to Gain a Better Understanding of both Grassland Degradation and Restoration Processes

Sustainable Grazing Strategies to Mitigate Impacts of Shrub Encroachment

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Global change alters the composition of grassland vegetation in mountain and low-input areas worldwide. Shrub encroachment is a common phenomenon due to increased temperature, reduced labour input and more demanding livestock breeds. Our recent survey across the Swiss Alps showed that shrub types differ in their impact on ecosystem services. Green alder (Alnus viridis), the most abundant successional shrub in the European Alps, reduces plant species richness most clearly, primarily due to enrichment by symbiotically fixed atmospheric N2. However, understory vegetation in alder stands provides an underestimated forage, rich in protein and similar in productivity and digestibility to nearby open pastures. A grazing trial with cattle, sheep and goats in alder-encroached subalpine pastures demonstrated that robust grazing animals were able to exploit the understory forage resources as they readily penetrated the thickets. Animal-borne sensors as well as proximal sensing techniques revealed that goats and local Engadine sheep consumed green alder bark and thus actively counteracted shrub encroachment. Another trial highlighted the importance of breed in feeding preference and movement behaviour: Comparing cattle breeds of different productivity on upland pastures showed that low-productive Highland cattle fed less choosy, more on shrubs and more evenly in space compared to high-input breeds. Hence, accounting for the genetic background of animal physiology and behaviour is clearly needed to design sustainable grazing strategies for shrub encroached areas. Our investigations demonstrate that low-input grazing systems utilizing robust breeds add to conservation goals and sustain a viable agricultural production in marginal areas.

Environmental Drivers Determining Vegetation Patterns of Natural Grasslands Utilised for Cattle Grazing

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Over 80% of agricultural land is in natural grasslands, and approximately 70% is in developing countries where they support livestock production. Due to the landscape structure, natural grassland communities are typically dynamic and demonstrate high spatial and temporal heterogeneity. The main objective of the study was to determine environmental factors influencing patterns of natural grasslands vegetation utilised for cattle grazing. MATERIALS AND METHODS: Vegetation surveys in natural grasslands, were conducted in two agroecological zones of Eswatini, the Highveld at Mankayane (26° 40' 6" S, 31° 3' 53" E) and the Middleveld at Luve (26° 19' 60" S, 31° 28' 20" E). The surveys were conducted for two seasons (2020/2021 and 2021/2022), using 100 m transects placed in north, east, west and south directions, in each natural grassland. Diversity indices were used to analyse vegetation species occurrence, while soil properties [soil

pH, texture, nitrogen (N), phosphorus (P), potassium (K)], climatic (elevation, rainfall, temperature) and socio-ecological [slope, landcover, topographic wetness index (TWI) distance of natural grasslands from settlements, water bodies and roads, grazing pressure] factors were used to determine vegetation distribution. Stacked-SDMs were implemented to predict optimal locations for multiple natural grassland vegetation species using abundance, species richness and environmental variables. Results and discussion: The main drivers for species assembly were P, temperature, soil pH, elevation, texture, distance of natural grasslands from water bodies and roads. The potential species richness of each grid per study area ranged from low potential (0 species) to high potential (8 species). At Mankayane approximately 75% of the sampled natural grasslands had highest potential species richness, while at Luve, more than 50% of the sampled natural grasslands had lowest potential species richness. Conclusion: Seven out of fifteen environmental drivers predicted natural grassland potential species richness. The heterogeneous species assembly at Mankayane avails a wide variety of species for cattle grazing while the homogeneous community at Luve provides fewer species.

Increased Lentification Alters Tadpole Diversity Within the Brazilian Cerrado, a Tropical Savanna Transformed by Agriculture

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Agricultural development has caused the loss and degradation of grasslands and savannas worldwide. The trend is especially acute in the Brazilian Cerrado, a global biodiversity hotspot, where half of the native vegetation has been converted to agricultural land use. The Cerrado has >200 amphibian species, many of which are sensitive to land-use changes that degrade their terrestrial and aquatic breeding habitats. We investigated the relative influence of pond environmental factors and the composition of the surrounding landscape (250-1000m) on the diversity and distribution of tadpole communities within 66 ponds across an agricultural gradient in the central Cerrado. Although a mix of environmental and landscape variables were identified as potentially important to local richness, only the interaction between hydroperiod and water pH, and the amount of cropland within a 250-m radius of ponds, were significant. Species richness declined with increasing cropland and with increasing water pH, but only in permanent ponds. Importantly, water pH increased with increasing agricultural land use at this same scale (r = 0.33, P = 0.022). Tadpole communities also exhibited high beta diversity (81-86% dissimilarity in species composition), with spatial turnover rather than nestedness accounting for 90-97% of species differences between ponds. Using db-RDA, we found that hydroperiod was largely responsible for spatial turnover (P = 0.003), with the first axis explaining 48.6% of community differences between sites of different hydroperiods (P = 0.002). Six species accounted for 70% of the dissimilarity between permanent and temporary ponds, with most species being either more abundant or found only within temporary ponds. Permanent ponds in this region are constructed by damming small streams, largely for

irrigation and livestock. Thus, agriculture is affecting the diversity and distribution of anuran larvae in the Cerrado via altered water chemistry and through the creation of more permanent ponds across the landscape (increased lentification).

Cross-Scale Interactions and Ecological Thresholds During Grassland Degradation Process of the Qinghai-Tibetan Plateau

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A significant body of literature has attempted to identify the underlying causes of extensive grassland degradation on the Qinghai-Tibetan Plateau (QTP). However, from a complex systems perspective, we propose that the degradation process can be understood as locally formed bare-soil patches expanding to the landscape level through various biological-environmental reinforcing feedback processes. For example, there are reinforcing feedback between intensified yak grazing, reduced vegetation height, and accelerated pika dispersal, and between intensified yak trampling, increased water stress in topsoil, and the replacement of grass and sedge by unpalatable plants. These reinforcing mechanisms are more prominent than single anthropogenic or environmental variable, such as stocking rate or pika density, in driving the scaling up of degradation. In our study, we illustrate this state-and-transition process of grassland degradation in Nyanpo Yutse of the eastern QTP. Using high-resolution (10 cm level) multi-spectral

UAV images, we first identified the sizes and locations of bare-soil patches in the study area's heterogeneous grassland landscape. We then demonstrated how the upscaling of bare-soil patches can be simulated using a cellular automaton model, considering both the cross-scale interactions and the variation of topography. We found that the proportion and spatial configuration of bare-soil patches can be related to the threshold of irreversible grassland degradation. Our study suggests that degradation is not caused by single "underlying causes", which have to be tackled. Rather, sustainable grassland management under such harsh climatic conditions, as on the QTP, has to be based on an encompassing system understanding and careful monitoring for early warning signs, indicating looming negative feedback loops.

Develop Spatial Disturbance Model of Yak to Explain Vegetation Dynamics in Qinghai-Tibetan Plateau

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Nearly 90% of alpine meadows of the Qinghai-Tibet Plateau (QTP) has degraded to varied states. Most of the existing research focuses on the driving force and pattern analysis of grassland degradation. From the perspective of ecosystem resilience, the degradation can be conceptualized as a state-and-transition process in which different feedback mechanisms drive the proportion change of bare-soil patches in a grassland matrix. However, knowledge regarding the state-and-transition mechanism underlying the formation of bare-soil patches in heterogenous landscapes remains scarce.

By introducing the perspective of spatial scale, we strive to construct the pathway of this state-and-transition mechanism related to the QTP grassland degradation. In this study, we integrated multi-disciplinary approaches including UAV remote sensing, and movement ecology study of livestock grazing behavior using GPS trackers and accelerometer. First, we examined both the resolution and the extent component of scale effects which influence the identification of bare soil patches and grassland degradation states. Second, combining fine spatial resolution UAV images and fine-temporal scale livestock trampling and grazing data, we simulated distribution models of grazing intensity in heterogeneous landscapes of different grassland degradation states and varied topographic features. Our results showed that the selection of scale strongly influence the identification of bare soil patches. The spatial distribution of grassland degradation states were sensitive to both the change of extent scale and resolution scale. In addition, the livestock disturbance model predicted the intensity of livestock's feeding and trampling in the landscape with high accuracy and robustness. Taking topography into account, southeast- facing slopes were more prone to severe degradation. This research has significant practical meaning for the establishment of ecological standards such as grazing intensity and disaster warning of grassland degradation in the QTP.

Effects Of the Size and Configuration of Bare-Soil Patches on Soil Properties and Microbes During the Degradation of Tibetan Alpine Meadows

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The rapid and large-scale degradation of Tibetan alpine meadows has severe ecological and socio-economic implications. While much research has been conducted on the topic, the mechanisms of degradation vary across different scales, and few studies have focused on the effects of spatial heterogeneity on a small scale at which herbivore-plant-soil interactions take place. Furthermore, different size and spatial arrangement of bare-soil patches can be related to low to high water and temperature stresses imposed to Kobresia sedges at the soil-plant interface. This study aimed to investigate the effects of bare-soil patch size and configuration on soil properties, microbial community composition, and functions during the formation of bare-soil patches during the degradation of Tibetan alpine meadows. We collected soil samples from six different levels of bare-soil coverage, ranging from 0% to >80%, and each soil core sample was divided into three parts: 0-5cm, 5-10cm, and 10-20cm. The spatial configuration of bare-soil patches was extracted from georeferenced ortho-images of 1 x 1 meter. We analyzed physical and chemical properties of all soil samples, and conducted metagenomics sequencing to detect microbial community compositions. We find that both size and spatial configuration of bare-soil patches have significant influence on soil properties and microbe communities. Overall, our study provides a new perspective to understand the underlying mechanism of grassland degradation which is related to spatial patterns of bare-soil patches. It highlights the importance of using the size and spatial configuration

of bare-soil patches to identify early-warning signals of Tibetan alpine meadow degradation.

Plateau Zokor (Small Burrowing Mammal), are they Competing with Livestock for Forage, or, Because of Diet Differences, Increasing Livestock Palatable Forage?

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Herbivores can coexist, compete, or facilitate each other depending on their diet. Herbivores assemblies can shape grassland plant community composition and structure. Despite a lack of evidence, small herbivores, often called rodents, are regarded as one of the causes for Qinghai-Tibetan Plateau (QTP) alpine meadows degradation. Plateau zokor (Eospalax baileyi) is distributed in the wetter part of the QTP, where yak (Bos grunniens) and Tibetan sheep (Ovis aries) are the dominant livestock. However, how plateau zokor impacts plant community in livestock grazed grasslands has not been experimentally studied. In this research, we ask (a) what is the effect of plateau zokor on the plant community composition? (b) what is the effect of plateau zokor on livestock palatable biomass? (c) how large is the soil disturbance of plateau zokor and how much does this reduce livestock palatable biomass? We set up 17 experimental fields in Henan County, Qinghai Province in 2021. Each field included one 50 by 50 m control area with plateau zokor present, whereas the local government eradicated the zokors from the rest of each field. The original plateau zokor density was 20.23 per hectare, on average 71% of the zokors were killed.

The bare land patches average 3.7 % of fields in all fields. Our study will provide a knowledge base for grassland degradation mitigation and sustainable grassland management.

Understanding Tibetan Herders' Landscape Perceptions to Inform Community-Based Grassland Restoration

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Nearly half of the alpine meadows on the Qinghai-Tibetan Plateau are degraded to various levels, posing threats to ecosystem services, biodiversity, and local people's livelihood. This has got increasing ecological concern and restoration investment. A growing number of literature suggests that community-based restoration should be strengthened. However, local herders' perspectives on degradation and restoration are understudied. Our research aims to uncover this knowledge and explore ways to enable local adaptive action. Applying photo-based survey, we conducted 97 interviews about herders' perceptions of the current grassland situation, their tolerance of degradation, and expectation of restoration. The results show that 1) a shifting baseline syndrome exists in area with high landscape heterogeneity that younger people are more tolerant to degradation; 2) willingness of earlier actions occurs in area with higher landscape heterogeneity; 3) there is a general risk of delay in herders' restoration

actions; 4) herders have a weak perception of the resilience of the ecological system. Hence, we argue that a lack of perception of the need for restoration may be a source of barriers to community-based restoration. Particularly, policymakers should consider different perceptions associated with local landscape features. The strengthening of human-place connections, and learning about ecological processes are also important to achieve timely and effective restoration.

When Money Meets Tradition: How New Cash Incomes Could be Risky for a Vulnerable Ecosystem

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Economic incentives to simultaneously address poverty and biodiversity loss may fail if they do not align with local values or norms. Grazing livestock across the Tibetan Plateau's vast but fragile grasslands is often characterized as the area's primary driver of habitat degradation. China's grassland restoration policy provides eco-compensation subsidies for herders, with the assumption that providing extra cash income will help alleviating grazing pressure. We investigated potential impacts of this supplementary income, in combination with caterpillar fungus, a major local cash income source, on the pastoral livelihood on the Tibetan Plateau. Through field livestock census in seven communities and household livelihood interviews with 153 households we found that at both household and valley levels, eco-compensation didn't have the intended effect of reducing grazing pressure, while caterpillar fungus income has significant positive relationships on grazing intensity. Meanwhile, we found significant decrease of above-ground plant biomass after policy implementation was linked with low elevation pastures with most intensive grazing, which indicated a negative impact of grazing on grassland condition at our study sites. Further, based on herdsmen's perceptions on different cash income sources we suspected those non-pastoral incomes might have even subsidized pastoralism. We suggested future economic incentives related to grassland restoration should be more targeted towards villages with low cash income and overgrazed grasslands, with clearly stated responsibilities and obligations, instead of standardized cash payment.

New Challenges for Restoring Wooded Meadows to Mitigate Climate Change

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The land use changes during 20th century had led to the disappearance of seminatural meadows. In 1950ies there were 1,108,400 ha seminatural grasslands, most of them paludified and peatland meadows. Nowadays the national management plan of protected seminatural habitats sets a goal to maintain about 60,000 ha of meadows, but only 4.2 % of protected meadows have been paludified meadows. The species that depends on wet grasslands are disappearing rapidly. In order to maintain the biodiversity of wet grasslands, the use of peatlands should be

intensified.Today the wooded meadows are maintained and restored mainly in mineral soils in western part of Estonia. Historically most of pastures and hay meadows were with sparse tree cover. For example, the study of agricultural records from 1939 demonstrated in test areas in Southern Estonia, that 28% of pastures and hay meadows were with trees.Today 84 % of fens in Estonia are drained, lost its natural water regime and are important carbon emitters. The land reclamation systems (4,500,00 ha in agricultural lands) that were established in Soviet Period, are amortized and land owners are interested to reconstruct them. At the same time the Climate Policy in Estonia aims to neglect the peatlands and plant trees to the low-value farmland.Until now, wooded grasslands have been restored by thinning forested areas. The new approach of restoration basis on features of traditional wooded wet grasslands – to plant the deciduous trees on drained peat soils following the features of traditional wooded grasslands.   Such agroforestry practice allows to continue the use of drained fens without renovation the melioration systems, support the carbon sequestration and serve the habitats for biodiversity. The trees provide shelter for livestock in increasing hot summers, improve the water regime due to evaporation, increase diversity growing conditions for grass layer. The ecosystem services provided by drained peatland will increase which is the goal of modern intensification of land use.

Successional Post-Quarry Sites Offer Ecological Benefits for Avifauna; Surrogate for Strategic Landscape Restoration

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Derelict landscapes comprising post-quarry sites undergo natural successional processes producing new habitat types whose ecological role remains largely unravelled especially in the sub-Saharan region. The objective of this study was to investigate seasonal variation in avifauna composition of post quarry sites in Ndarugu, Kenya, and compared to non-quarried sites. Birds were censused in 166 and 116 distance sampling point count stations using the fixed-radius point count method in the long rain (S1) and short rains (S2) seasons. The proportion of different land use land cover (LULC) types within each point count provided the environmental variables applied to explain bird distribution. Birds were classified into functional guilds, avifaunal composition assessed and the bird data subjected to multivariate analysis. Avian species, from 46 and 54 families were recorded in S1 and S2, respectively. A total of 156 bird species, 128 in post-quarry and 119 in non-quarried sites, were recorded in S1, while 168 species, 141 in post quarry and 114 in non-quarried sites were recorded in S2. Bush and forest related species represented more than 50% of total observed birds in both site categories. There was significant effect of season and land type category on bird species richness, abundance and Shannon weaver diversity with all measures higher in post-quarried than in non-quarried sites (p<0.05). Non-metric dimensional scaling (NMDS) analysis distinguished the functional groups of birds whose species richness was related to spatial occurrence of specific land use land cover types. Patches of successional post-quarry sites contributed

significantly to species community structure, critical for conserving species populations and should therefore be integrated in landscape ecological restoration designs of extraction-degraded sites.

Key words: post-quarry sites, emergent habitats, birds, biodiversity, ordination, ecological restoration

Evaluation of the Ecosystem-Resilience and Landscape Design for the Disaster Mitigation Across a Huge Tsunami Disturbed Sand-Dune Ecotone

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The Great East Japan Earthquake/Tsunami on March 11, 2011 severely destroyed the fringe of Sendai Bay, northeast Honshu, Japan. In the present landscape ecological study, (1) multi-scale heterogeneity both in the events of destruction and rapid natural regeneration of vegetation was examined across a semi-natural seaside sand-dune ecotone, and (2) a design for the disaster mitigation toward multi-functional and integrated ecotone management was proposed under the concept of 'multi-layered disaster defense system' and 'ecosystem-based disaster risk reduction.'In June 2011, Minami-Gamou/Sandy Beach Coastal Ecotone Monitoring Site was set in Shinhama, Sendai City (38°14.1′N, 140°59.5′E; ca. 550m in length and ca. 700m in depth). Then, field surveys (e.g., flora, specific composition and community structure of vegetation, die-off and regeneration for woody plants, and disturbance of ground-surface; Tomita et al., 2013, 2014; Onza et al., 2014; Kanno et al., 2014) and remote sensing analyses (e.g., fine-scale landform change, and distribution of vegetation and NDVI; Sato et al., 2018; Hirabuki et al, 2019) have been performed in conformity to catena landscape structure. Measures for conservation of species and habitats in the reconstruction work of 'grey-infrastructures' have been also evaluated their effectiveness (Oka and Hirabuki, 2015, 2017; Matsushima et al., 2019; Yamanouchi et al., 2022). Heterogeneous vegetation and landform changes were caused mainly by subsidence, surface scraping, sediment deposit and up-rooting of tall-tree, and their patterns varied clearly among catenas. Traits of both damage (e.g., collapse and runoff) and natural regeneration (e.g., sprouting from subterranean organs and germination from buried and/or disseminated seeds) for component individuals were also varied, although numbers of species remained and/or shifted coupling with heterogeneity in fine-scale landform disturbance. We proposed disaster mitigation models, which could (1) preserved survived plants, safe-sites and the on-site sand, and (2) enhanced diversity, redundancy and connectivity of coastal ecotone.

Transform a Tidal Embankment into a Green Infrastructure

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Coastal landscapes, which are disturbed ecosystems, are known for their high resilience to natural and anthropogenic disturbances of the ecosystem. However, the ecological and social impacts of low-frequency large-scale natural disturbances at the level of the Great East Japan Earthquake that occurred on March 11, 2011, and the subsequent anthropogenic alterations caused by extensive disaster restoration projects (construction of seawalls on beaches, land filling with sediment from inland sources, and monocultural planting of black pine trees on reclaimed land), are still unknown in the world. On the other hand, there is concern that these structures may disrupt the continuity of the marine and terrestrial ecosystems. This presentation will report on the effectiveness of a method of covering the slope of a tidal embankment with sand to promote the establishment of vegetation in order to mitigate the ecological impact of the tidal embankment, a concrete structure built on the beach, and to restore the continuity of the ecotone. As a result, plant establishment was confirmed in all study sites by covering the slope of the tidal embankment with sand. However, differences were observed in the plant species that appeared and their coverage rates depending on the origin of the sand used and the construction method. Where beach-derived sand was used, beach plants predominated and appeared, although coverage rates were low, but when inland-derived sand was used, alien species predominated at high density, and little establishment of beach plants was confirmed. Even when beach-derived sand was used, alien species other than beach plants dominated at high density when mats with organic matter enclosed in the sand were used as

planting substrates. Since the number of years after construction is still short, future changes should be carefully monitored.

Environmental Education at Elementary Schools for the Sustainable Management of Coastal Landscapes in Collaboration with Local Residents

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After the Great East Japan Earthquake, conservation and restoration activities of coastal landscapes have been conducted with local residents on the Sendai coast of Miyagi Prefecture, Japan, which was damaged by tsunami disaster. Local elementary schools are involved in these activities as part of their environmental education program since 2016, with schoolchildren growing and transplanting coastal plants. It has been pointed out that environmental education for children changes their knowledge and impressions of the natural environment. However, studies examining the effects of environmental education over multiple years is lacking, and it is considered important to understand the effects of such education in order to achieve sustainable management of coastal landscapes. The aim of this study is to clarify the effects of environmental education on schoolchildren, by understanding the changes in their knowledge and impressions of the coastal landscapes according to the number of years they had participated in the activities. Questionnaire survey was conducted on 4th graders (1st year of participation), 5th graders (2nd year of

participation), and 6th graders (3rd year of participation) at Okada Elementary School in Sendai city, Miyagi Prefecture, Japan. The main questions were related to knowledge of coastal plants and their landscape image of the coastal landscapes. To measure the amount of knowledge about costal plants, schoolchildren were presented with photographs of eight native species of costal plants and asked if they had seen each one and knew its name. The schoolchildren were asked to describe their landscape image by drawing a picture. As a result, the amount of knowledge of coastal plants increased year by year through environmental education, and several schoolchildren's landscape image depicted costal plants. Environmental education over multiple years resulted in a change in the amount of knowledge and the impression about the coastal landscapes suggesting the effectiveness of environmental education.

Impacts of Anthropogenic Modification on the Nutrient Sources and Distribution of Coastal Insects on the Coast of Sendai Bay

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Sandy beaches are the boundary between sea and land, and stranded organic matters are important as nutrient sources for their terrestrial ecosystems. Macroinvertebrates living near the shoreline feed on such matters, and the marine nutrient inflow can also support insects further inland through the food web. On the Pacific coast of the Northeastern Japan region, the construction of tidal embankments and the creation of coastal forests with mounding were conducted as the restoration and reconstruction project after the Great East Japan Earthquake. The aim of this study is to examine the impacts of these anthropogenic modifications on the marine nutrient inflow to coastal insects and the distribution of them. We selected several study sites on sandy beaches along the coast of Sendai Bay, differing in the presence or absence of embankments and coastal forests. At each study site, we set survey lines vertically to the shoreline and sampled insects using pitfall traps along the lines. In addition, we estimated the contributions of marine-derived nutrients to each individual for species found on both sides of the embankment using the stable isotopes of carbon and nitrogen. Results showed that the contributions on the landward side of the embankment were as predicted by the data from the site without the embankment. Some species of coastal insects were also found on the landward side of the embankment, but their abundance was lower than on the seaward side and significantly decreased on the mound of the coastal forest. We conclude that habitat for coastal insects as vectors of the marine nutrient inflow is important on the landward side of embankments, and the creation of coastal forests with mounding may cause the loss of such habitat.

The Natural Resilience of the Vegetation on the Coastal Dune After Andaman Tidal Waves 2004

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The natural recovery of the coastal dune vegetation has been monitored since the Andaman Tsunami in 2004 on the coastal dune at Khao Lampi-Had Tai Mueng National Park in Pang Nga, Peninsular Thailand. The tidal waves on December 28th, 2004, on the Andaman coast completely swept through the whole coastal dune in the mentioned place. The natural vegetation was disturbed much by the saline water of the tidal wave current. All elements of the ground cover, shrub vegetation, and all under canopies species were swept away, as well as woodland species of tree that lost their leaves and, in some species, branches. After three months after the event, the monitoring of the natural resilience of the vegetation has taken place. The species composition and the forest profile of the recovering vegetation were observed every three months four times, then afterwards, once a year up until now. However, during the pandemic crisis 2019-2022, no investigation is occurring in the areas according to the coronavirus controlling regulations. It is suggested that the ground cover of the coastal grassland next to the shoreline recovered back in the first three months of monitoring, while other woody species took seven years to recover in the same situation before the tidal wave event in 2004. Things that destroyed the structure of the vegetation on the dune were not the tidal waves but the reforestation programs afterwards. In the place where human reforestation occurred, the natural vegetation has been disappearing.

Impacts of Armed Conflicts on Landscapes

Evaluation of Implications of Armed Conflict in Ukraine on Landscapes

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The 2022 Russian invasion of Ukraine already resulted in large-scale devastation, human deaths, economic losses and humanitarian catastrophe. However, it also has probably impacted the functioning of environmental systems and had a negative impact on landscapes. Here we evaluated the state of land use all over Ukraine before and after the 2022 armed conflict, namely from 2018 to 2022, with multitemporal composites of Sentinel-2 imagery and random forest classifier. Next, we allocated approximate positions of front lines in different periods of armed conflict (until December 1st, 2022) and quantified with spatially-explicit econometric models the spatial distribution of abandoned lands and armed-conflict-induced wildfires. Our analysis was complemented by evaluating armed-conflict-impacted landscapes by calculating landscape indices, including morphological analysis. The results showed that after 2022 some patterns of cropland abandonment and wildfires, detected with MODIS products, were close to the front lines. The landscape ecological analysis showed that combat activities took place in already fragmented landscapes, such as the South and South-East corners of Ukraine, where croplands dominate the landscapes and remnants of forests and grasslands form small patches. Therefore, armed conflict in Ukraine has another strong negative pressure on the remaining seminatural vegetation, possibly reducing its resilience and adaptation to adverse climate effects projected in the South and South-East of Ukraine and causing the losses of biodiversity.

Keywords: resilience, landscape, drivers, armed conflicts, remote sensing.

The Influence of Military Actions on the Natural Landscapes of Ukraine

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War brings not only direct threats to the life and health of Ukrainian citizens from explosions, destruction, shelling, detonation of mines and other types of hostile actions. As a result of military actions, there is the destruction of industrial facilities – oil depots, plants, factories, warehouses, mines, infrastructure facilities – water pipelines, gas pipelines, water purification stations, water supply stations, the destruction of numerous buildings, which is accompanied by powerful fires, emissions of dangerous substances into the atmosphere substances, spills of fuel and lubricants, the entry of untreated sewage into rivers, which leads to pollution of water, atmosphere, soil and can cause numerous diseases and poisonings, as well as entry of carcinogenic elements into the body. During the hostilities, nature conservation territories of international national and regional importance are

damaged – UNESCO biosphere reserves, territories of the Emerald network, wetlands of international importance, nature reserves, national parks and other territories of the nature reserve fund, as well as territories valuable for birds along the Dnieper and the coast of the Black and Azov seas, which are part of the Afro-Eurasian migration route. There is a complex impact on all components of nature – air, soil, water, biodiversity, surface sediments, climate and relief of territories, which leads to chemical pollution of the environment, powerful physical impact and direct destruction of individual objects. The primary tasks of landscape ecologists are:1) studying the effects of military operations on the environment, identifying and preventing threats to the life and health of citizens and damage to natural ecosystems;2) together with lawyers, collecting data on environmental crimes, recording violations, collecting evidence, calculating damages;3) study of practices for restoration of natural complexes.

Evaluation of the Relationship Between Fire, Land Use and Armed Conflicts in West Iran

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Political instability enhances the risk of armed conflicts, which not only pose a great threat to human livelihoods, but are also capable of negatively impacting the environment, hence making it essential to examine their ecological effects (Mitri et al., 2011). Armed conflict and its influences on ecosystems are compound and challenging to examine due to limiting accessibility to the concerned regions given the danger of active fighting (Gorsevski et al., 2012). Thus, remote sensing offers an appropriate measure to assess both direct and indirect impacts of conflict on the ecosystem (Gorsevski et al., 2012). One environmental aspect induced by armed conflicts is fire occurrence, through actions such as large population movements away from the violence-affected area, enhancing the susceptibility of nearby vegetated areas, such as for agricultural fields, where lack of workforce and lack of access result in heightened fire risk (Mitri et al., 2011). Not only are these ecosystems more susceptible to fires under armed conflicts but intended forest fires can also play a crucial part in military strategy (Dinc, 2021; Mitri et al., 2011). This is further amplified by the fact that once a fire has been ignited, it is often difficult for local authorities to control its extent and successfully extinguish it (Mitri & Gitas, 2008).Nonetheless, the association between armed conflict and fire and land cover in West Iran has not been extensively studied, although previous focus areas in the Middle East have covered Israel, Syria, Lebanon, Turkey and Iraq (Dinc, 2021; Eklund et al., 2021; Levin et al., 2016; Mitri et al., 2011; Zubkova et al., 2021). The purpose of this thesis is to help fill the research gap in this region by evaluating how landcover and fire dynamics in West Iran interact with armed conflict through the following hypothesis: armed conflict leads to increased fire occurrences that are driven by more than just climatic variables. Data surrounding conflict events is acquired from a combination of two geocoded event databases UCDP and ICEWS, where the former gives insight into armed conflict events that were characterized by at least one fatality and the latter includes diverse political acts. Climatic data included temperature and precipitation data on monthly resolution. Using tools such as spatial

GIS analysis, bivariate global and local Moran's I and Spearman rank correlations, a statistically significant spatial relationship was found between armed conflict and fires incidents, represented as localized clusters of high conflict and high fire occurrence. Moreover, these clusters did have lower correlations to the climatic variables compared to the provincial level, implying the local effect of armed conflict. The analysis showed that the correlation between fire outbreaks in the conflict-affected areas and temperature was either significant but weaker compared to the whole province, or not significant at all. Similarly, the correlation between fire occurrence and precipitation in high conflict and high fire clusters was observed to be significantly less negatively related or not substantially present. Therefore, the results highlight that in localized clusters, climatic variables fail to explain fire occurrence, suggesting that the impact of conflict on fire events is spatially confined and does not affect areas further away.

Conflict-Related Environmental Degradation Could Impede Future Peacebuilding in Tigray (Ethiopia)

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Armed conflicts can lead to environmental degradation, threatening the basis of people's livelihoods and wellbeing, and thus create barriers to sustainable peacebuilding. Identifying areas where conflicts drive environmental degradation is important for designing effective recovery strategies, but is inherently challenging in insecure contexts. We here use a case study in Tigray, Ethiopia, to illustrate how open source remotely sensed data (here: satellite imagery) can be used to support the identification of conflict-driven environmental degradation in situations where ground-based assessments are difficult or impossible. In Tigray, landscape-scale restoration, including widespread reforestation, has been successful at increasing water availability and agricultural yields. However, forest resources have come under threat since the start of the civil war in 2020, as blockades have severely limited non- timber sources of fuel. We identified areas of potential woody vegetation loss that have occurred during the conflict based on open-source satellite imagery. Areas of potential woody vegetation loss extend across 930 km2 (ca. 1 % of Tigray's total area) and appear to
be mostly concentrated in hotspots along major roads. Given the importance of woody vegetation for landscape health in this region, the continued loss of trees during the conflict could threaten restoration-driven gains in agricultural productivity in the long term. Eventual peacebuilding efforts will have to consider the loss in landscape health during the war and include efforts to restore lost woody vegetation to ensure both food security and livelihoods. This will require not only restoring woody vegetation directly, but also the economic and social infrastructure that underpinned past successes in landscape recovery in Tigray. Satellite imagery, together with ground-based data collection, could inform such post-war restoration efforts by helping to identify degraded areas at a regional scale.

Assessing the Impact of Conflict on Local Food Production in Badakhshan: 1967-2013

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The Badakhshan region of eastern Tajikistan and northeastern Afghanistan continues to experience acute food insecurity due to a nexus of environmental and socio-economic factors. A critical component of this nexus is armed conflict, resulting from the Soviet invasion in 1979 which affects Afghanistan acutely. Conflict driven displacement leads to agricultural land abandonment and an increase in fallow plots, impacting local food production. The boundary between Afghanistan and Tajikistan, set in 1873, provides a control landscape for testing the significance of conflict's effect on the Afghan landscape compared to the ecologically and culturally similar but conflict-free Tajikistan. To test for armed conflict's effect on local food production, I construct a 46 year time series of changes to food production across the whole of Badakhshan. I estimate food production by classifying agricultural land cover and attaining vegetation indices (Vis) from CORONA and Landsat archival imagery. Analysing high resolution CORONA imagery allows us to ascertain the extent of food forest cover, rangeland, and arable land across the landscape. Having established this baseline, we analyse the Landsat archive to measure where and how land cover has changed over time. This output provides a quantitative overview of how local food production has changed both temporally and spatially. In addition to agricultural land cover, other important vegetation indices are analysed to more accurately ascertain growing conditions. Finally, historical archival data is used to determine the drivers of these land cover changes, while Residual Trend analysis (RESTREND) is applied to Landsat Vis to establish which shifts in productivity are anthropogenic. This research provides a deeper understanding of how past conflict has acted as a driver of food insecurity in the region. Additionally, it allows for future work to build o of these findings and predict how future conflict might have an impact. These findings can inform humanitarian and development aid policy, while the methodology can be applied to other contexts where conflict is present.
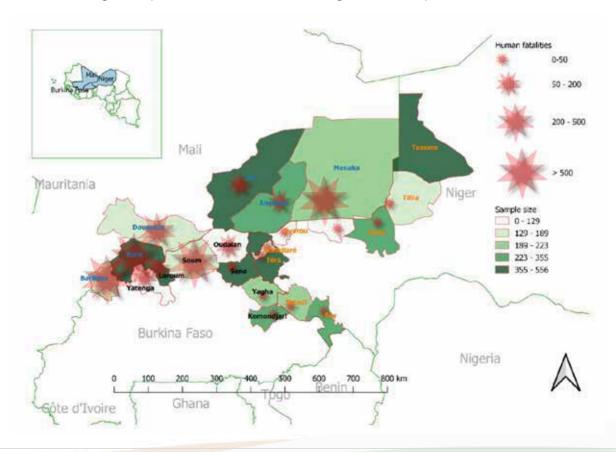
Livelihood Responses Among Vulnerable Communities in Three Regions of Mali: Evidence from A Primary Survey

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The issue of responses and resilience to major insecurity for pastoralist communities in the Sahel has been neglected in the scholarship due to complexities in measuring short-term and long-term responses. Sahelian pastoralist communities have developed long-term practices and adaptations to living in the resource-scarce Sahel, where aridity and infrequent and unpredictable rainfall make reliability difficult. Recent political and environmental shocks – population growth, extremism, political violence, communal violence, droughts/floods, and urbanization – have all complicated and perhaps disrupted traditional

resilience practices. This study integrates primary survey data from three regions of Mali (Sikasso/Bamako, Ségou, and Mopti) with the Armed Conflict Location and Event database (ACLED) on political violence to examine both impacts and responses of insecurity among vulnerable communities in Mali. Specifically, the survey asked many questions about impacts of security (type of major insecurity event, where it happened, responsible actors, what was the impact in terms of loss of resources and livelihoods) and responses. Questions about responses to insecurity related to diversifying livelihoods, selling resources or land, secondary employment, mobility or migration, joining militias, and taking loans. Mobility and livelihoods are two critical dimensions of pastoralist (and others including farmers and traders) livelihoods, and this study empirically measures the impact of recent shocks. Significantly, this study also examines the impact of the Malian conflict since 2012 on livelihoods and mobility for pastoralist communities, including the impacts on resources, land, herding, and other aspects of livelihoods.

<u>Improving</u> Biodiversity and Ecosystem Services Monitoring for Sustainable Landscapes on the Road Towards 2030 Conservation Targets

Deep Learning in Remote Sensing the Vereda Wetlands: Mapping and Monitoring the Neotropical Palm Swamp Landscapes

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New measures are urgently needed to face the Cerrado's current critical scenario of exponential degradation of its highly diversified Neotropical savannas, whose coverage has already been reduced to nearly half of its original extension and projections indicate that most of it will have disappeared by 2050. Traditional organism-level approaches, while essential, are not feasible for immediate action given the 2 million km2 scale of these savannas. It is argued that autonomous satellite remote sensing approaches at systemic levels, combined with computer vision techniques, making use of semantic segmentation by means of convolutional neural networks and deep learning algorithms, should be taken as an essential, near real-time way of assessing and monitoring biodiversity. Thus, following this line of reasoning, added by autonomous adaptative connectivity objectives, the first results of an experimental mapping study focused on the Vereda wetlands are presented here. These wetlands are of unique strategic importance for conservation for several reasons, including ecosystems services such as storing-filtering excess rainwater and, thereby, functioning as reservoirs of impressive amounts of carbon stock in organic soils; but primarily because they represent the landscapes distributed in direct association with the drainage systems of the headwaters of the main Cerrado river basins. Based on non-analytic input data represented by 282.66 Km2 of Veredas, distributed in a core region of the Cerrado, a series of experiments have been successfully performed at different geographic scales applying deep learning algorithms with ·80% mapping accuracies and resolution reaching 0.6m. Extra fieldwork efforts are currently implementing refined validations for an agenda to have the designed autonomous mapping system running in Beta mode by June 2023, which should provide a dynamic Sentinel-2 assessment for the Veredas at multiple scales in the South American continent.

Remote Sensing Indices for Environmental Grassland Monitoring in Europe

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Grasslands cover large parts of the land surface in Europe. They are of great value in terms of biodiversity, water management, carbon storage, fodder for livestock, biomass for energy production, or other ecosystem services. Grasslands in Europe are under severe pressure. Depending on the area, abandonment followed by succession or intensification are major threats. In addition, unusually low rainfall has been recorded in recent years, causing degradation especially in the Mediterranean region. Environmental indicators provide a way of describing complex environmental conditions in simpler terms. They are becoming increasingly important for understanding and managing human- environment systems. Remote sensing is an inexpensive and rapid way to monitor environmental indicators related to grasslands. Remote sensing indices are derived from remote sensing signals by offsetting two or more bands, by examining a band at different time steps or spatially. They reduce the complexity and dimensionality of using different bands, but also help to filter out the most important information or add new information. Through a literature review, we provide an overview of remote sensing indices used in environmental monitoring of European grasslands. We relate the indices acquired on different scales from drones to satellites to specific environmental indicators of interest for nature conservation. To date, we have finalised the constraints for the literature search, categorised the resulting papers and prepared the analysis structure. We expect to present a new scheme for the categorisation of remote sensing indices, which facilitates the comparison and overview of commonly used indices and refers to the underlying (biophysical, biochemical, physiological) abstraction mechanisms. We will give recommendations for remote sensing indices depending on natural conditions and grassland types and clarify peculiarities and pitfalls of remote sensing monitoring of grassland indicators. The results will help researchers and users to identify the most useful indices for their application.*Keywords: Remote Sensing Indices, Environmental Indicators, Grassland, Europe.*

Divland - Research Project of Complex Landscape Monitoring and Assessment for Environmental Resilience

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Abstract
The aim of the project is to create a research centre that will generate outputs which can be used for strategic planning in the field of nature conservation, landscape and biodiversity, as well as for solving actual problems arising in the landscape and its ecosystems.The specific objectives of the centre's activities include in particular (1) the development and establishment of standardised landscape monitoring at the national level, (2) the assessment of the dynamics of forest ecosystems and agroecosystems in the context of climate change,

including the level of their degradation, (3) the design of a long-term complex assessment of the status and changes of biodiversity, and (4) the identification of significant factors threatening biodiversity, with an emphasis on the issue of biological invasions. The analytical tasks will result in (5) development of comprehensive monitoring tools, (6) development of methodological basis for strategic decision-making and finally (7) proposal of management measures to mitigate the impacts of climate change on landscape and ecosystems in the Czech Republic.The contribution focuses on the presentation of selected research tasks, specifically on the topic of the impacts of landscape dynamics on biodiversity changes. Preliminary results show the need for stratified biodiversity monitoring and the importance of developing appropriate proxy variables that can at least partially replace existing field data collections on biodiversity and landscape characteristics.

Scaling of Categorical Spatial Data - Effects on Information Content, Representativeness and Class Detection from Multispectral Data

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Modeling the effects of land cover changes on ecological processes, populations or communities across time often requires the spatial scaling of categorical land cover data. Since class definitions are scale- dependent, up-scaling categorical data must account for that dependence to represent the land cover condition at the lower spatial resolution. However, most decision rules that aggregate categorical data do not produce scale-specific class definitions but label the larger grid cell with one of the original class labels from the higher resolution data, which leads to high loss of cover information. In contrast, the multi-dimensional grid-point (MDGP) scaling algorithm generates scale-specific class definitions on the basis of frequently occurring relative abundances of classes at the higher resolution. We evaluated the tradeoffs in class precision (how much original information is retained in a scaled grid cell) and class representativeness (the minimum proportion of the larger landscape that a scaled class must occupy to be maintained) on compositional information loss and class detection accuracy of scaled classes from multispectral Landsat data. We compared performance of the conventional majority-rule with the MDGP-scaling algorithm. For two study areas in the Florida Everglades (USA) wetland, the MDGP-scaling retained between 3.8 and 27.9% more compositional information than the majority rule as class-label precision increased. Increasing class-label precision and information retention also increased overall spectral class detection accuracy from Landsat data by up to 8.6%. Rare class removal and increase in class-label similarity were controlled by the class representativeness threshold, also leading to higher detection accuracy as class representativeness increased. When up-scaling categorical data across natural landscapes, negotiating trade-offs in thematic precision, landscape-scale class representativeness, and increased information retention in the scaled map results in greater class-detection accuracy from lower-resolution, multispectral, remotely sensed data. MDGP-

scaling provides a framework to weigh tradeoffs and to make informed decisions on parameter selection.

Developing Methodology for Assessing the Impact of The Nature-Based Solution on the Aquatic and Borderland Ecosystems: Case Study of Latvia

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Latvia is facing a challenge to meet the ambitions set by the Water Framework Directive (2000/60/EC) to reach good water status, and to prevent deterioration. In Latvia, only 30% of water bodies are assessed as having good water quality. Various studies have shown that nature-based solutions (NBS) are used as a support tool to improve quality of disturbed ecosystems. Efficiency of NBS to improve ecological conditions in water body is planned to be evaluated within the project LIFE GOODWATER IP. The envisaged measures include environmentally friendly drainage system elements (meandering, artificial rapids, two-stage ditches, bottom dams, sedimentation ponds), green infrastructure elements in forest and agriculture lands (bufferstrips, constructed wetlands, overland flow areas), and solutions to reduce effects of hydrological and morphological modifications (fish passes, reconstruct culverts, improvement of riverbed). To evaluate the effectiveness of the implemented measures and their impact on ecological quality of water bodies a twofold ecosystem services (ES) assessment approach is applied - before and after the implemented activities - to assess the ecosystem response in the future. Methodology foresees the use of 40 indicators, partially related to ES potential and partially – to ES flow. ES assessment spatial unit is divided in three scales: i) a riverine/lake, ecosystem under water surface; ii) a floodplain, 50% probability of flooding (floods with recurrence every 2 years); iii) a river valley landform, well-developed valley fillings and river terraces. Individual ES assessment monitoring have been applied of each of 17 projects water bodies created by more than 25 involved experts. One of the challenges in developing ES assessment methodology is the uncertainty in evaluating the effectiveness of the implemented measures. Simultaneously advanced assessment methods are required to identify biological quality elements that are sensitive to hydromorphological and eutrophication pressures, which can be integrated into river basin management plans for comprehensive ecological quality assessment.

Keywords: water bodies, water quality, nature-based solutions, impacts on the aquatic environment

Citizen Science Data: A Growing Opportunity to Manage Landscapes for Animal Movement

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The effective conservation of wildlife requires knowledge about animal movement across landscapes, for connectivity is essential to maintain gene flow and species' ecological roles. However, and despite substantial advances in tracking technologies and molecular analyses, we still lack key movement data that may be used in conservation strategies against population declines and local extinctions. An opportunity to generate information for data- poor species and regions has arisen through the increasing popularity of citizen science databases, which now hold millions of occurrence records over broad geographical scales. For example, there is almost no information on hummingbird movement in the Neotropics, despite widespread patterns of seasonality in occurrence, their ecological importance as pollinators, and their sensitivity to habitat degradation and loss. Using citizen science data, we modeled monthly changes in altitudinal distribution and ecosystem use for hummingbirds in the Andes Mountains Range, a global hotspot for biodiversity that continues to be threatened by changes in climate and land use. We employed analytical tools to deal with implicit spatiotemporal biases and machine learning methods to model species distributions. Our results show patterns of altitudinal movement and changes in ecosystem use for hummingbirds at a continental scale. In addition, we found that natural landscapes have greater hummingbird seasonality in comparison to anthropogenic land covers, and hummingbirds with seasonal ecosystem use tend to exhibit decreasing populations. Therefore, our study highlights the importance of habitat quality and ecological connectivity between different ecosystem types for conserving these avian pollinators and their seasonal movements. It also demonstrates how citizen science data may be analyzed to increase our understanding of seasonal species' occurrences so that landscapes are managed to protect animal movement. Challenges that remain include directing more citizen science sampling efforts towards remote regions and rare species as well as integrating findings more efficiently to nature management and policy.

Key words: *citizen science, ecological connectivity, animal movement, Neotropics, machine learning*

Investigating the Relationship Between Tree Species Diversity and Landsat-8 Spectral Heterogeneity Across Multiple Phenological Stages

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Abstract: The emergence of spectral variation hypothesis (SVH) has gained widespread attention in the remote sensing community as a method for deriving biodiversity information from remotely sensed data. SVH states that spectral heterogeneity on remotely sensed imagery reflects environmental heterogeneity which in turn is associated with high species diversity and therefore could be useful for characterizing landscape biodiversity. However, the effect of phenology has received relatively less attention despite being an important variable influencing plant species spectral responses. The study investigated i) the effect of phenology on the relationship between spectral heterogeneity and plant species diversity. Stratified random sampling was adopted to survey all tree species with a diameter at breast height of >10cm in 90m X 90m plots distributed throughout the study site. Tree species diversity was quantified by Shannon diversity index (H'), Simpson index of diversity (D2) and species richness (S). SAM and CV were employed on Landsat-8 data to compute spectral heterogeneity. The study applied linear regression models to investigate the relationship between spectral heterogeneity metrics and species diversity indices across four phenological stages. The results showed that the end of the growing season was the most ideal phenological stage for estimating species diversity following the SVH concept. During this period SAM and species diversity indices (S, H',D2) had an R^2 of 0.14, 0.24, 0.20 respectively while CV had an R^2 of 0.22, 0.22, 0.25 respectively. Although the coefficient of determination was comparatively low, the relationship between spectral heterogeneity metrics and species diversity indices was statistically significant ($p < 0.05$) and this supports the assertion that SVH could be implemented to characterize plant species diversity. Importantly, the study highlights that remote sensing captures spectral variability related to the diversity of tree species in the savannah woodlands with implication that remote sensing model based on spectral variability would be more suited for modelling tree species diversity in the savannah woodlands particularly in the end of growing season; iii) tree phenology affects the ability of remote sensing to capture spectral variability related to tree species diversity and therefore the implementation of SVH should target particular phenological period to increase the chances of extracting spectral variability related to tree species diversity

Ecology from Space: Improving Biodiversity Monitoring Towards 2030 Conservation Targets

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Increased access to satellite imagery and new developments in remote sensing data analyses can support biodiversity conservation targets by providing monitoring capacities at various spatial and temporal scales. More satellite imagery is indeed becoming available as open data, while remote sensing based techniques that capitalise on the information contained in spatially-explicit species data, such as Global Biodiversity Information Facility (GBIF), among other biodiversity related Big Data are developing constantly, and offering a plurality of application options. Current free and open data policy will have a dramatic impact

on our ability to understand how biodiversity is being affected by anthropogenic pressures and climate change, while improving the capability to predict the consequences of changes in drivers at different scales. We need to gain knowledge on ecosystem conditions and the impacts of various human pressures on these systems to be able to plan for more efficient mitigation measures for all global change drivers at different landscape levels. Using a mixture of remote sensing and field-based data requires ecologists and remote sensing experts to collaborate closely to make the best use of the newest remote sensing capabilities and modelling approaches. This presentation will serve to introduce the session and provide insights into the CEOS initiative on ecosystems extent mapping.

The Sustainability of Mediterranean Mountain Landscapes: IoT Herd Monitoring Challenges

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Mediterranean mountain landscapes feature pastoralism, and the maintenance of sheep and goat grazing is the main challenge for their sustainability. To provide their ecosystem services, mainly to reduce the risk of fires in the context of global change, we need to couple the herds' size and impact with the ecosystems foraging status in real-time. It means to herd more efficiently to maintain these landscapes resilient. Understanding complex grazing processes at a landscape scale can now be aided by the various sensors and trackers available. The development of geo-location technologies makes it possible to combine information at different scales on time to adapt pastoralism more efficiently in the context of rural abandonment. In this paper, we analyze artificial intelligence-based IoT data from the daily routes of three flocks of goats and sheep over a year in the mountains of central Portugal. A principal components analysis of the temporal geolocalisation of the herds discriminates the spatial scale of the territorial selection attributed to the herders and the animals, analytically confirming what has been described empirically by several authors. The results confirmed the relevance of these operational solutions for understanding complex landscape processes and efficiently supporting sustainable management. Finally, our result shows that these innovative tools are reliable for monitoring animal ecosystem services in Mediterranean mountain landscapes in support of policy decisions on their remuneration.

Supporting Biodiversity Monitoring for 2030 Conservation Targets through a Comparative Analysis of Connectivity Metrics

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The Kunming-Montreal Global Biodiversity Framework aims to protect 30% of terrestrial land and water globally by 2030. Along with the area-based targets, the framework recognizes the need for protected areas to be well-connected to offer effective solutions to the intersecting biodiversity and climate change crises. A challenge for land managers, policy- and decision-

makers is how best to measure connectivity, and gains in connectivity, as they expand the protected area network. Currently, researchers use more than 50 metrics of varying levels of complexity to measure connectivity, which complicates protected area administrator management decisions. We undertake a systematic comparison of 17 of the most widely used connectivity metrics to evaluate how they measure change in connectivity as protected areas are added to a network. Using an iterative approach, we simulate change in three protected area networks and statistically evaluate metric variation using Pearson's correlation and factor analysis. We determine the mathematical components of each metric that drive correlation with other metrics and identify how the metrics group together when used to measure protected area network expansion. We find that area rather than distance or more complex measures, such as dispersal probabilities, drives the correlation between many connectivity measures. We find that simple, area-based measures also often produce results that are statistically similar to more complex metrics, suggesting that basic measures can suffice for monitoring changes in network connectivity in support of 2030 targets.

Using Remote Sensing Data with Machine Learning to Predict Distribution of Red-Listed Forest Species

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Essential Biodiversity Variables (EBVs) have been dev eloped during the last decades. So far, six classes of EBVs have been defined but is still in development, while some variables are still rather conceptual. Due to the complexity of biodiversity, traditional biodiversity monitoring programs and ecological field studies have been seen as insufficient and spatially uneven. At the same time, biodiversity change is often detected when damage is already irreversible, such as when species become locally or regionally extinct. As such, it is imperative to improve our understanding on how natural and anthropogenic drivers determine the spatial and temporal trends of biodiversity. In this work, we focus on the potential of remote sensing and machine learning as tools to bridge these gaps and advance our capabilities to understand biodiversity processes. Methodology: To understand what the key drivers and their synergistic interactions on species distribution are, we use state-of-the-art geostatistical techniques (machine learning and deep learning approaches such as Geographical Random Forest) to investigate the relationships between the various indicators and occurrence rate (Red-listed species data). The independent variables include forest data, soil and surface data, land cover data and climate data. Response variable is species occurrence data based on observation of 28 near-threatened birds. These data mentioned above are used as training and testing data for machine learning. When links are established and key drivers are clarified, we work on the analysis of

anthropogenic drivers v s nature drivers and recall the gaps of current EBVs development. The same time, we build a prediction tool based on how species-distribution responds to environmental variables (the respond curves from regression), and predict the distribution of red-listed species due to global warming. *Keywords (5): Biodiversity, Red-listed species, Remote sensing, Machine learning, Forest ecosystems*

Species Distribution Models Using Remote-Sensed Dynamic Habitat Index

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Species Distribution Modeling (SDM) constitutes an important tool for biodiversity monitoring, based on the statistical correlation of species occurrences with environmental predictors. The radiometric indices of vegetation and soil can be used to synthesise annual variations by calculating Dynamic Habitat Indices (DHIs), which have shown good correlation with animal species richness at regional scales. DHI uses a combination of vegetation indices, such as the Normalized Difference Vegetation Index (NDVI) to create a map that identifies areas with high habitat quality and connectivity. The map is then used to identify priority areas for biodiversity conservation. In this study, we hypothesized that the DHI used as indicator can improve the prediction accuracy in SDMs. We developed a comparative framework for two types of SDMs, based on predictors obtained from commonly used data (Land Cover classification - LC) and from remote sensing (RS)

data, i.e. DHIs. The study area used to demonstrate the approach, is the French region of Île-de-France, which is encroached by intensive agriculture and urban areas. We computed predictor sets based on classified LC and RS Sentinel-2 data. Initial analyses showed similar SDM prediction accuracy between the standard LC and RS based approaches. However, further analysis showed that the niches predicted by SDM from RS were larger than those predicted by SDM from LC. We determined that this difference was due to a threshold effect of binarization of potential presence scores on the distance variables to the LC classes. DHI, as a predictor in SDMs, may therefore be more suitable than LULC predictors for identifying species niches on a regional scale, which can be used in biodiversity monitoring. Overall, DHI can be a valuable tool for conservation as an operational method, providing an objective and efficient way to prioritize conservation efforts and monitor changes in habitat quality over time.

The Future Forest Floor: Coupled 21st-Century Climate and Forest Change Project Thermophilization and Homogenization in a Mountain Landscape

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Protected areas are central to global biodiversity conservation, but their future conservation potential is threatened by climate change, increasing disturbances, and legacies of human management. Climate warming is particularly pronounced in mountains such as the European Alps, a plant diversity hotspot with many cold-preferring species. Projecting future change is critical but challenging for forest understory plants, which respond to microclimate conditions mediated by forest structure and composition that may be decoupled from macroclimate change. Here, we coupled climate and forest change using the process-based, forest landscape and disturbance model iLand in a 20,808 ha Northern Limestone Alps landscape (Berchtesgaden National Park, Germany) to ask: (1) How do understory plant communities respond to 21st-century changes in climate and forests? (2) How important is macroclimate versus forest change in driving understory responses? Stacked individual species distribution models fit with climate, forest, and site predictors (248 species, 150 widely distributed field plots, overall AUC = 0.86) were used with projected climate and modeled forest drivers to predict plant community change. Landscape mean species richness and understory cover declined (-14% and -8%, respectively, by 2100), and warm-adapted species increasingly dominated plant communities (i.e., thermophilization, +15%). Mean plot-level turnover was high (0.63), and on average 30% of all species and 50% of red list species were lost from the landscape. Higher elevations experienced the greatest richness declines, most thermophilization, and highest turnover, resulting in plant community homogenization across elevation zones. Climate change was the dominant driver of changes in richness and thermophilization relative to forest change, but both were important for cover. Even in protected areas, the magnitude of 21st-century change is likely to erode the ability of mountain forests to conserve biodiversity. Considering both climate and forest drivers alters expectations about understory plant community change, with important implications for future ecosystem functioning and services.

Impacts of Landscape Connectivity Modeling's Choices on Conservation Planning

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Landscapes are changing under the pressures of anthropogenic land use and climate change. Hence, the survival of species is threatened by the cumulative effects of habitat destruction, degradation and isolation. Within these fragmented landscapes, tools are needed to get insights supporting conservation. Connectivity analysis is a valuable tool that allows understanding of the spatial distribution of habitat patches and their potential functional linkages across the landscape matrix. Here, we compare connectivity estimations and the associated potential land management implications to support conservation planning. To explore these questions, we used a real-case study as a demonstrator. We considered the mid-wife toad (Alytes obstetricans) within a 300km² rural area in western France. We divided

the connectivity evaluation framework into three steps: landscape characterization, pairwise connectivity modeling, landscape connectivity estimation. First, we defined patches of suitable habitat and resistance coefficient using two commonly used methods: expert's opinion and species distribution models. Second, we implemented Euclidean distances, least-cost paths, circuit theory and a stochastic movements simulator to assess the pairwise interpatch connectivity. Finally, we analyzed connectivity maps and computed the composition of patch's contribution and probability of connectivity index to identify structural elements supporting landscape connectivity. Along with the framework, we identified overlooked parametrization steps to support implementation. We emphasized the importance of presenting this step and justifying the methodological choices according to the data, as well as their ecological relevance. The comparison of expert vs distribution models allowed us to point out converging and diverging outcomes, highlighting the complementarity of both approaches. Finally, the analysis of patch's contribution allowed us to rank the patches according to their contribution to intra- and inter-patches connectivity. Each combination of models provided a different hierarchy potentially leading to different managerial priorities which reinforce the importance of clarity and transparency for the implementation of connectivity modeling for conservation purposes.

Modelling the Breeding Habitat of the Black Grouse from Remote Sensing Data

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The Black Grouse (Lyrurus tetrix) is an emblematic alpine species with high conservation importance. The population size of these mountain bird tends to decline on the reference sites and shows differences according to changes in local landscape characteristics. Habitat changes are at the centre of the identified pressures impacting part or all of its life cycle, according to experts. Hence, an approach to monitor population dynamics, is trough modelling the favourable habitats of Black Grouse breeding (nesting sites). Then, coupling modelling with multi-source remote sensing data (medium and very high spatial resolution), allowed the implementation of a spatial distribution model of the species. Indeed, the extraction of variables from remote sensing helped to describe the landscapes studied at appropriate spatial and temporal scales: horizontal and vertical structure (heterogeneity), functioning (vegetation indices), phenology (seasonal or inter-annual dynamics) and biodiversity. An annual time series of radiometric indices (NDVI, NDWI, BI ...) from Sentinel-2 has made it possible to generate Dynamic Habitat Indices (DHIs) to derive phenological indications on the nature and dynamics of natural habitats. In addition, very high-resolution images (SPOT6) provided access to the fine structure of natural habitats, i.e. the vertical and horizontal organisation by states identified as elementary (mineral, herbaceous, low and high

woody). Actually, one of the essential limiting factors is the presence of a well-developed herbaceous or ericaceous stratum, which is essential for brood rearing. A deep learning model was used to classify elementary strata. Finally, Biomod2 R platform, using an ensemble approach, was applied to model, the favourable habitat of Black Grouse reproduction. Results from the habitat model can be used as an operational tool for monitoring landscape shifts and changes. In addition, to delimiting potential areas to protect the species habitat, which constitute a valuable decision-making tool for conservation management of mountain landscapes.

Keywords: Remote sensing, modelling, spatial distribution, Black grouse.

What Do We Need to Assess Landscape Structure Across Boundaries? A Region-Based Multi-Scale Case Study from Poland

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The latest evaluation of the European Environment Agency (EEA, 2020) shows that Europe's nature is in serious, continuing decline. Progressive landscape fragmentation and isolation result from gradually reducing the natural-environment surfaces (Haila, 2002; Jaeger et al., 2011; Bruschi et al., 2015; Hilty et al., 2020). The EU Biodiversity Strategy for 2030 remarked that "to have a truly coherent and resilient Trans-European Nature Network, it will be important to set up ecological framework to prevent genetic isolation, allow for species migration, and maintain and enhance healthy ecosystems" (EC, 2020).Even though each EU Member State is legally obliged to assess the state of its environment, the knowledge about long-term LULC changes in the entirety of the ecological network still needs to be improved (Kleijn et al., 2014; Kubacka & Smaga, 2019; Kubacka et al. 2022). There is a particular need to quantify landscape fragmentation, in an ecologically meaningful way, for inclusion in planning and decision-making. Our research hypothesis assumes that spatial planning affects the state of fragmentation and isolation of the national ecological network on local, regional, and international scales to determine the integrity of its spatial structure. Until now, there has been no research covering such time intervals (last 20 years) and so high data resolution, i.e., up to 5 meters accuracy for the area of approx. 30,000 sq km. Although internally diverse, the natural environment of the selected region, i.e., Wielkopolska, is typical for other lowland areas. Therefore, the results obtained have a universal character. We also reviewed the available GIS tools for calculating landscape metrics with high data resolution for vast areas to maintain the continuity of ecological network. Moreover, we compared generally available databases regarding the possibility of achieving the research goal. Finally, our results prove that the mapping unit and the methodology of attributing the dominant type of land cover to each polygon significantly influence the value of indices.

Keywords: ecological network, sustainability, landscape planning and management, landscape metrics, land use/land cover changes.

Biodiversity and Geodiversity: Co-Management Approaches for Resilient Landscapes

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Landscapes consist of abiotic and biotic attributes, combined in different patterns, under various conditions, depending on natural processes and human induced activities. Moreover, landscape modifications are recorded to be faster than ever before, ignited not only by the aforementioned parameters, but also by the well documented impact of climate crisis and biodiversity loss. This study aims to provide input for biotic and abiotic landscape components, using biodiversity and geodiversity as key indicators for landscape assessments, including corresponding ecosystems' condition, actual and/or potential supply of ecosystem services, in the frame of the LIFE-IP 4 NATURA national project, in Greece. Using well established biodiversity indicators (e.g., plant species richness, endemic plant species richness) and geodiversity (e.g., geological richness, relief complexity, mineral activity importance), we developed a national scale thematic map highlighting co-existence spatial patterns of biodiversity and geodiversity hot-spots (bio-geo-diversity hot spots), for the first time in Greece. Moreover, special focus is given to the prioritization of the Natura 2000 network sites regarding their importance on biodiversity and geodiversity characteristics. Bio-geo-diversity hot-spots and cold-spots are also documented outside protected areas, pinpointing sites, and landscapes of conservation importance. The results of the study: (a) support with spatial explicit data, scientifically informed decision and policy making for holistic conservation measures and actions (i.e., including both abiotic and biotic attributes), and (b) guide future research on ecosystem services identification and integrated management, at the national scale. By this an adequate framework for resilient landscapes is supported, recognizing equally the importance of biodiversity and geodiversity co-management.

Keywords: MAES, Greece, landscape indicators, mapping

Improving Landscape Sustainability & Resilience to Climate Extremes & External Shocks Across the Urban-Rural Continuum

How Can Landscape Ecology Contribute to The Sustainability Research of The Urban-Rural Continuum?

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As the global urbanization level continues to rise from the current 56% to the projected 68% in 2050, urbanization will undoubtedly be an even more dominant driver for future environmental and socioeconomic transformations. These transformations inevitably affect, and are affected by, landscape composition and configuration. During recent decades, urbanization worldwide has not only dramatically increased the number and size of cities, but also accelerated the coalescence of individual cities into complex urban agglomerations which often encapsulate built-up, suburban, and rural areas. More than ever, urban and rural areas are increasingly interactive, forming urban-rural continuums. Although urban landscape ecology has been booming in the past several decades, evidence is mounting that focusing separately on urban areas, rural areas, or the transitional zone between them is not adequate for understanding and practicing sustainability at landscape and regional scales. Thus, in this presentation I argue that landscape ecology needs to "scale up" to embrace urban-rural regional systems and urban agglomerations as study objects. Landscape ecology needs to contribute to Sustainable Development Goals (SDGs), particularly SDG 11a that aims to: "support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning". In order to achieve this goal, though, landscape ecological studies must explicitly consider the reciprocal flows of organisms, people, and a variety of ecosystem and socioeconomic services that define urban-rural linkages. I conclude the presentation with a framework and a set of key research questions.

Lasting Cities Along the Core Silk Roads: An Overview Through the Lens of Urban-Rural Continuum (URC)

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Silk Roads, a major human infrastructure connecting Europe with East Asia, played important role in promoting human civilization and society formation. Among the many routes, the 14800 km long one that rans from the Mediterranean coast to Xian in western China is the core. Over 560 modern cities fall in a 100-km buffer zone (2.79 million km2), including nine capital cities of the 11 countries. Some of these cities have long history, being established prior to the Silk Roads. For example, Baghdad was one of the earliest societies before Persian empires, and Xian in China and Tehran in Iran served as the bases of major empires. Geographically, these routes were shaped by avoiding major deserts (e.g., the Karakum Desert) and glacier mountains (e.g., the Tianshan), allowing for minimal exposures to climate extremes and easier access to water that in other parts of the Asian Drylands Belt

(ADB). In this study, we examined these cities through the lens of urban-rural continuum (URC). Multiple social-environmental conditions along eight directions from the urban center to rural landscapes were explored for anisotropic changes, their interdependencies, and the spatial aggregations of the URC in different parts of the Silk Roads. As expected, four clusters are seen on the Mediterranean's east bank, the south bank of the Caspian Sea to the Tigris River, Toshkent to the west slope of Tianshan, and the west of Xian. Waterways play a critical role in the anisotropic features of URC, with the geomorphic features further modulating the changing rate and divergencies among and within URCs. Although these cities are located in different countries and have diverse cultural backgrounds, their lasting and recent growth (population and GDP per capita) appear to be highly correlated with current temperature and precipitation, vegetation (leaf area, GPP), soil moisture, and rich water resources.

What Does it Mean to be Urban? Searching for the DNA of Urbanisation

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What is urbanization? Most often has been understood as a process of population shift from rural to urban areas. This very simplified understanding, however, is complicated by conceptual imprecisions – in spatial, thematic and temporal aspects. Current conceptualisations of urbanisation have relied on broadly accepted categorical differentiations in which cities are conceived as well-defined objects containing urban spaces and in contrast (in terms of drivers and processes) to their hinterlands, the so-called rural areas. However, the multidimensional complexity of urbanisation challenges the socially biased urban analytical apparatus in the context of increasing social issues marked by uneven development, inequality, commodification, etc., that required fresh scientific and policy answers. In this piece, we performed a conceptual journey from the population-based and LULC-based understandings of urbanisation, with an emphasis on the origins of this categorical understanding and why this needs to be changed. We provide an overall framework compiling particular urbanisation patterns and processes, referring to urban form, to urban expansion, informal urban development and urban green space, concentrating on the complexity and challenges posed by urbanisation. These reflections, which are based on empirical findings, discuss mostly the shortcomings of using categorical variables to define urbanisation; spatial complexity, with an emphasis on spatial delimitation; urbanisation occurring in remote wild areas; and the missing third spatial dimension of urbanisation. Our analysis of urbanisation has a focus on the material dimension, where urbanisation can be linked to the metabolism of the urban ecosystem. We characterize urbanisation as a continuous spatiotemporal phenomenon opening new avenues for understanding the spatial organisation of socio-ecological systems, informing globally generalisable patterns of landscape-scale urbanisation

processes. The development of appropriate indicators to measure urbanisation as a continuous spatiotemporal process is crucial in developing a new science of cities.

Building Volume, Transportation, and Green Spaces: Factors Affecting Urban Heat Island in a High-Density Metropolis

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Urban heat island has increasingly become a more severe urban environmental challenge especially due to more frequent intense summer heat experienced by many cities due to global warming. The paper proposes a framework to examine the contribution of urban landscape features, including 3D features, to urban heat island (UHI) in high-density, transit-oriented metropolises, using Shanghai, China as a case. In addition to factors that have been widely acknowledged in UHI studies, such as green space and transit stops, we incorporated building volume to examine how urban landscape features have contributed to UHI. We derived UHI data from remotely-sensing images. Employing geospatial modeling and multiple linear regression analyses, we examined how proportion of green space, number of bus stops, number of subways stations, number of road intersections, and building volume have affected UHI spatial patterns during both daytime and nighttime. We found that the number of road intersections and building volume have a positive impact on daytime UHI while number of road intersections, number of bus stops, and building volume contributed positively to nighttime UHI. We also found that numbers of subway stations and level of greenness alleviated daytime UHI while only the green space performed the same function for nighttime UHI in Shanghai.

Landscape Sustainability Science and the Urban-Rural Continuum

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As the global urbanization level continues to rise from the current 56% to the projected 68% in 2050, urbanization will undoubtedly be an even more dominant driver for future environmental and socioeconomic transformations. These transformations inevitably affect, and are affected by, landscape composition and configuration. During recent decades, urbanization worldwide has not only dramatically increased the number and size of cities, but also accelerated the coalescence of individual cities into complex urban agglomerations which often encapsulate

built-up, suburban, and rural areas. More than ever, urban and rural areas are increasingly interactive, forming urban-rural continuums. Although urban landscape ecology has been booming in the past several decades, evidence is mounting that focusing separately on urban areas, rural areas, or the transitional zone between them is not adequate for understanding and practicing sustainability at landscape and regional scales. Thus, in this presentation I argue that landscape ecology needs to "scale up" to embrace urban-rural regional systems and urban agglomerations as study objects, and also actively contribute to Sustainable Development Goals (SDGs), particularly SDG 11a that aims to: "support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning". I'll discuss how landscape sustainability science can help to achieve this goal, and conclude with a set of suggestions to move forward.

Landscape Sustainability in Sub-Saharan Africa: Implications of Landscape Change in Peri-urban Areas of Accra

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African countries are expected to experience the fastest urban growth rates worldwide, with 950 million more people living in African cities by 2050. These growth patterns may combine in situ urbanisation, the place-based transformation of a rural into an urban area, with urban extensification, the lateral expansion of urban areas into many rural lands. Accra, the capital of Ghana, is one of these rapidly expanding cities on the continent, with a projected 49.3% increase in population to 3.5 million from 2005 to 2025. This growth was partly spurred by major infrastructure development, especially new intercity highways at the turn of the 21st century. Such rapid urban transition presents significant socioeconomic and environmental sustainability challenges, especially along the rural-urban gradient.Based on the availability of cloud-free satellite data, GIS and remote sensing technologies were used in this study to determine the pattern of urban sprawl in Accra and its environs. Land Use Land Cover (LULC) classification was carried out over a 50-year period (1982-2022). The dynamics of landscape change around Accra were then investigated along four national highways (N1, N2, N4, and N6). The N1 highway connects Accra to Winneba in the west and Sogakope in the east. The N2 highway starts in Tema at the Tema Motorway interchange and runs north-east through Afienya to Kpong; the N4 highway starts in Accra at the Tetteh Quarshie Interchange and runs north through Adenta to Koforidua before joining the N6 at Asokore. Finally, the N6 highway heads north-west to Nsawam and Kumasi. The initial change analyses were followed by an assessment of urban sprawl patterns to determine the presence or absence of linear sprawl along the various growth directions from Accra. We then compared changes in green areas and sensitive areas,

such as flood zones, to changes in economic activity as manifested by an increase in commercial spaces. The findings revealed that built-up areas increased significantly during the study period. The study also demonstrates that urban sprawl has resulted in the reduction and disappearance of surface water bodies. Our presentation will discuss how these changes will affect the resilience and attainment of Agenda 2030 (SDGs) of communities in the Peri-urban areas of Accra regarding environmental shocks like flooding and water scarcity.

Spatio-Temporal Dynamics of Urban Heat Exposure Risk and Governance Strategy

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Heat wave caused by climate change and heat island effects caused by rapid urbanization pose serious heat hazards to human health in cities. Heat exposure risk assessment and governance are necessary to address the negative impacts of urban heat hazard events. Heat exposure risk is dynamic in time and space due to diurnal temperature variations and population mobility, but has often been ignored in previous studies. This study proposed a diurnal dynamic heat exposure risk assessment framework and identifies the spatial distribution of heat exposure risk in central urban areas of Beijing based on multi-source data. A zoning method was proposed for urban heat exposure risk governance based on the contribution of different Local Climate Zones (LCZ) to heat exposure risk and the dominant factors of heat exposure risk. Results showed that both day and night heat exposure risk gradually decreasing from the center outward, and the core functional area being the main contributor to high heat exposure risk. Compared with daytime, the center of heat exposure risk moved eastward at night. There was a significant positive autocorrelation in the spatial distribution of both the day and night heat exposure risks, namely, the high heat exposure risk areas affect the surrounding areas. The high-risk areas accounted for 28.84% of the total area of the study area and were mainly distributed in the central area of the study area, dominated by dense mid- and high-rise building types with only a small amount of low vegetation areas.The high-risk areas were classified as urgent, high, medium and low priority governance zones by using mitigation strategy and both public and individual adaptation measures. These findings could represent an important basis for developing risk mitigation strategies in urban planning, and provide effective guidance for urban residents to improve their risk adaptation capacity.

Key words: Heat hazards, Heat exposure risk, Population mobility, Local climate zone, Risk governance

From Spatial Change to Network Spread: Analysis of Network Characteristics of Heat Exposure Risk

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The frequency, intensity and duration of the heat wave are expected to increase in the future, and the superposition with urban heat island effect has a

significant impact on the urban environment and human health. As an effective measure for mitigating the negative effects of heat-related risk on human health, improving the urban environment needs more space and financial support. It is necessary to identify the spatial aggregation mode and dynamic change driving mode of heat exposure risk, and formulate mitigation measures according to the characteristics and change trend of heat exposure risk network to balance the mitigation efficiency and planning feasibility. This study identified the spatial pattern of summer heat exposure risk in Beijing in 2000, 2010 and 2018 through multi-period remote sensing data and morphological spatial pattern analysis. The dynamic change process of heat exposure risk is identified through the spatial pattern, and the synergistic effect of heat exposure risk and heat island effect in different time and space is analyzed. On this basis, it combs the network characteristics and diffusion network of heat exposure risk, and explores its diffusion trend and network effect from two aspects: the transformation of different levels of risk areas and the characteristics of different morphologic of heat exposure risk spatial pattern. The results show that the central areas of heat exposure risk are mostly densely populated areas and areas with significant heat island effect. The spatial distribution of heat exposure risk has a significant aggregation trend and has significant spatial autocorrelation characteristics. The increase of nodes and corridors and the expansion of patches enhance the network effect of heat exposure risk. From 2000 to 2010 and from 2010 to 2018, the thermal exposure risk showed a diffusion trend and the diffusion trend was further strengthened. This study provides an approach to identify network characteristics of heat exposure risk

and guide environmental improvement in highly urbanized city.

Spatial-Temporal Variations of Groundwater Storage in China: A Multiscale Analysis Based on GRACE Data

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Groundwater storage (GWS) plays a key role in the freshwater supply in China. Revealing the changes in GWS in China is critical for realizing scientific utilization of groundwater resources and regional sustainable development. This research mainly aimed to examine the characteristics of GWS changes at multiple scales. We used Gravity Recovery and Climate Experiment (GRACE) satellite data as well as HydroSHEDS datasets to quantify the variation of GWS in China from 2003 to 2020. We found that GWS was decreasing at an annual rate of -2.09 mm/a in China. Three hot-spot areas with dramatic GWS decrease, located in Northwest, Southwest and North China, accounted for 55.52% of the total GWS decrease in China, and the reduction in GWS in these areas was driven primarily by human activities. Additionally, more than half of the urban agglomerations in China presented a declining trend of GWS, especially Central Shanxi, Beijing-Tianjin-Hebei, Central Plains and Shandong Peninsula where GWS exhibited a dramatically decreasing trend. Therefore, it

is suggested that targeted measures should be taken according to local conditions to strengthen the scientific management of groundwater resources to promote the sustainable development of urban agglomerations.

The Supply and Demand of Water-Related Ecosystem Services in the Asian Water Tower and Its Downstream Area: A Multi-Scale and Multi-Scenario Analysis

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Climate change and human activities can have an impact on the supply and demand of water-related ecosystem services (WRESs) in the Asian water tower (AWT) and its downstream area, which is closely related to the production and livelihoods of billions of people. However, few studies have taken the AWT and its downstream area as a whole to assess the supply–demand relationship of WRESs. This study aims to assess the future trends of the supply–demand relationship of WRESs in the AWT and its downstream area. Here, we estimate the supply–demand relationship of WRESs in 2019 using the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model and socio-economic data. Then, we select future scenarios under the framework of the Scenario Model Intercomparison Project (ScenarioMIP). Finally, trends in the supply–demand of WRESs are analysed at multiple scales over 2020-2050. We found that the supply–demand imbalance of WRESs in the AWT and its downstream area will continue to intensify. The area with imbalance intensification was 2.38×10^6 km2 (61.7%). The supply–demand ratio (SDR) of WRESs will decline significantly under different scenarios ($p < 0.05$). The Ganges-Brahmaputra, Mekong and Salween basins of the AWT have the fastest rate of SDR decline. The main reason for the imbalance intensification in WRESs is the constant growth of human activities, with a relative contribution of 62.8%. Our findings suggest that in addition to the pursuit of climate mitigation and adaptation, attention should also be paid to the impact of rapid human activity growth on the supply–demand imbalance of WRESs. Reducing the negative impact of human activities on the supply–demand relationship of WRESs is essential to promote regional sustainable development.

Keywords: Asian water tower and its downstream area; Water-related ecosystem services; Supply–demand relationship; Future trend; Multiscale analysis

Building Urban Water Resilience in the Face of Climate, Demographic, Socioeconomic and Land Use/Land Cover Changes: A Multidimensional Approach

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To meet the needs of their citizens, many cities in developing nations, make significant investments in building new infrastructure and pay less attention to the development of sanitation infrastructure and important natural ecosystems, such as water. As a result, as the population grows, the sanitary and water conditions

deteriorate. Urban actors therefore need to look for strategies to curb such impacts in order to assure the water resilience of a city. Therefore, the goal of this study was to investigate the relationships between climate change, land use/land cover changes, socioeconomic changes, and the quantity, quality, and supply of water while also making some recommendations for how to effectively address these concerns. The relationship between LULC dynamics and water quality was evaluated using water quality index method, correlations and principal component analysis. Key informant interviews, field observations, and contingent value survey approaches were employed to assess resident's willingness to pay. The impacts of changing climate on streamflow and water quality were evaluated using the Soil and Water Assessment Tool based on CMIP5 models under Representative Concentration Pathway 4.5 and 8.5. The results showed that the water quality of the city has been deteriorating from a water quality index of 65.34 in 1991 to 246.76 in 2021. Built-up areas positively linked with water quality measures such as nutrient loading, turbidity, total alkalinity, and total hardness. From the interviewed residents, 89.58% were willing to pay and spend, on average, 158.28 ETB. Streamflow decreased significantly by 65.4 m3/yr (RCP 4.5) and 195.9 m3/yr (RCP8.5) from 2021 to 2040. In conclusion the capacity for water to support the industry, agriculture, ecosystems and the increasing number of residents in Addis Ababa city is near its limit under current management practices. Such information is crucial for directing management planning and modeling assessments of the potential future for the city to track the progress towards achieving Sustainable Development Goals 6 and assure water resilience.

Modelling Soil Organic Carbon Stock Distribution Across Different Land-Uses in South Africa: A Remote Sensing and Deep Learning Approach

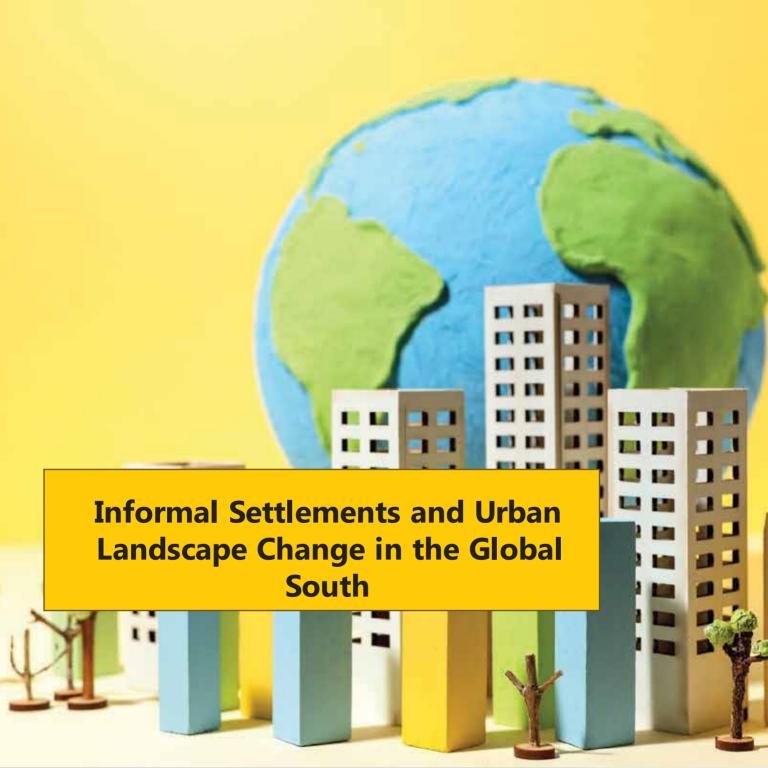Omosalewa Odebiri[1]*, Onisimo Mutanga, John Odindi and Rowan Naicker

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Soil organic carbon (SOC) is a critical measure for ecosystem health and offers opportunities to understand carbon fluxes and associated implications. However, SOC can be significantly influenced by anthropogenic land use change, with intensive and extensive disturbances resulting in considerable SOC loss. Consequently, understanding the spatial distribution of SOC across different land uses, particularly at national level characterised by different biomes, is vital for integrated land-use planning and climate change mitigation. Remote sensing and deep learning (DL) offer a reliable largescale mapping of SOC by leveraging on their big data provision and powerful analytical prowess respectively. This study modelled SOC stocks across South Africa's major land uses using Deep Neural Networks (DNN) and Sentinel-3 satellite data. Based on 1936 soil samples and 31 spectral predictors, results show a relatively high accuracy with

an R2 and RMSE value of 0.673 and 10.35 t/ha (26% of the mean) respectively. From the seven land uses evaluated, grasslands (31.36%) contributed the most to the overall SOC stocks while urban vegetation (0.04%) contributed the least. Moreover, although SOC stock was found to be relatively proportional to land coverage, commercial (46.06 t/h) and natural (44.34 t/h) forests showed a higher carbon sequestration capacity. These findings provide an important guideline to managing SOC stocks in South Africa, useful in climate change mitigation through sustainable land-use practices. Whereas landscape restoration, and other relevant interventions are encouraged to improve SOC storage, care must be taken within land-use decision making to maintain an appropriate balance between carbon sequestration, biodiversity, and general ecosystem functions.

Informal Settlements and Urban Landscape Change in the Global South

Building Resilience of Urban Food Systems – Controlled Environment Agriculture for School Feeding

Serah Kiragu-Wissler

Urban areas mainly depend on peri-urban and rural areas for food. But climate change, experienced through extreme weather conditions, particularly drought, is affecting crop production which is mainly based of open field production systems. This is threatening food security of not only rural but also urban livelihoods. We argue that food production in cities, done under controlled environment agriculture (CEA), can make a valuable contribution to building resilience of urban food systems. Specifically, we demonstrate how CEA in urban schools can contribute to meeting nutritious food demands for children in schools. This is based on our pilot research outcomes of hydroponic greenhouses we introduced to a school in the informal settlement of Mukuru, Nairobi, where we linked production to the school meal programme. For scaling and sustainability of such an innovation towards urban food security, we recommend need to link the initiative to institutionalised arrangements such as government-sponsored school feeding programmes.

When Informal Works for Good – Management of Urban Green for Ecosystem Services in Niamey and Agadez, Niger

Sylwia Kulczyk[*], Marek Kulczyk

Planning and management of urban green in a way that improves delivery of ecosystem services (and, consequently, the quality of life) is usually considered as responsibility of local administration. The failure of formal actions (eg. due to lack of funding or poor management) leads to deterioration of the already existing areas and is a barrier to create new ones. Our observations from Niamey and Agadez in Niger show that although the above-described process is very likely, this not necessarily means the total collapse of the urban green. Informal actions within this field are rarely recognized, yet powerful tool. To leave care of urban green to local community while allowing informal activities may actually help to build an efficient green infrastructure that may not be arranged with use of the formal instruments. Two Sahelian cities: the capital of Niger and the most important city of the northern part of the country are growing rapidly in the harsh conditions of the constant lack of funding for any governance actions on the socio-economic side and the unbalanced water regime as one of the environmental challenges. In such circumstances, informal actions appear to be far more effective than the formal ones. Individually taken, bottom-up actions which positively influence that expand green infrastructure in the urban areas in Sahel improve delivery of ecosystem services in many ways. First, urban agriculture and gardening helps to cover food needs of

the city. Second, individually planted trees support both regulatory and aesthetic functions of an urban ecosystem. While we not argue, that care of green infrastructure should be left in hands of urban dwellers, it is important to recognize the effects of their actions as important elements of the urban green infrastructure.

The Role of Open Data on Urban Deprivation: The Ideamapsudan Data Ecosystem

Asgad Gummah, Fatima Ahmed, Mosub Abdallah, Serkan Girgin, André da Silva Mano, Mustafa Hamza, Wafa Sakhi, Ibrahim Kushieb, Julia Kumi, Taha Elzaki, Inas M. M. Ali Nuha Eltiny, Serkan, Maysoon Badi, Jon Wang, Charlotte Flasse, Eléonore Wolff, Caroline Gevaert, Caroline Kabaria, Monika Kuffer

Khartoum, Sudan, one of the fast-growing African metropolises, has a fragmented urban development with a high level of inequality. In particular, the outskirts of the city, which have transformed from Internally Displaced Person (IDP) camps to informal settlements, are faced with high levels of deprivation, in terms of environmental, housing, and socioeconomic conditions. Spatial data to support the monitoring of environmental fragmentation as well as smart and sustainable urban development strategies, are very limited. In response, IDeaMapSudan was launched in 2020 to develop a community-led open geospatial information system for mapping deprived areas and their specific ground conditions that will support the decision-making processes. For this purpose, a multi-level deprivation model based on open-access geospatial and Earth Observation data has been created. The main innovation of this work lies in the co-creation of deprivation data together with local stakeholders and making it publicly available via standard web services (e.g., OGC WMS/WFS) and web applications (Geoserver and Geonode) to support local stakeholders and encourage data exchange on urban development questions. To deal with the political instability and resource constraints (e.g., common power cuts), a cloud-based solution was selected with the deployment of GeoNode on a server hosted in Europe, but managed by the local team of IDeaMapSudan. Through GeoNode, deprivation data, including deprivation index, is accessible to view and download at http://geonode.idea-maps.net, and metadata is also provided. The information system aims to promote data exchange in Sudan between various stakeholder groups interested in urban poverty alleviation. The approach offers a pathway for building locally relevant data systems and promotes open-access data in an environment where up-to-date data are often unavailable or not shared to facilitate sustainable urban development.

Morphological and Socioeconomic Patterns of Heat Exposure in Sub-Saharan African Cities

Sabine Vanhuysse

In low- and middle-income countries, communities living in deprived urban areas (DUAs) tend to be more exposed to high temperature variations and extreme weather events than urban dwellers living in planned areas. This issue is becoming more acute as the DUA population keeps increasing and climate change exacerbates thermal inequities. Several factors come into play, pertaining to household characteristics (e.g., housing materials, overcrowding) and area- level characteristics linked to the urban morphology and patterns (e.g., high built-up densities, irregular patterns that prevent ventilation). We develop methods that combine the use of remote sensing and fine-scale urban morphological indicators in machine learning models to investigate to what extent the urban landscape reflects deprivation and influences thermal disparities in such contexts, and to, ultimately, estimate the total population exposed. Our methods rely on the use of open or low-cost geo-datasets and satellite imagery, and free open-source software.We focus on three case studies in sub-Saharan Africa characterised by a diversity of urban landscapes, two in Kenya (Nairobi and Kisumu) and one in Burkina Faso (Ouagadougou). First, we derive land-surface temperature (LST) from MODIS and Landsat. Next, we model the extent and location of DUAs at city scale based on a set of morphometrics (e.g., spatial metrics calculated on building footprints and their neighbourhood) and imagery, and we analyse the correlation between LST and DUAs. To quantify the exposed population, we use existing global products, and we also develop bottom-up deep learning models based on micro-survey data. First results on Nairobi indicate positive associations between deprivation, population density and LST.This study aims at supporting evidence-based decisions and contributing to monitor the progress towards the achievement of SDGs 11 and 13. At the local level, the objective is to stimulate the debate on low-cost urban design favouring adaptation to climate change.

Mapping Open and Big Data in African Cities

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In rapidly evolving data-driven economies, such as those found in many African countries, the role of Big Data cannot be underestimated. Especially in building urban resilience and creating opportunities to address pressing issues such as urbanisation, population growth, and access to and use of resources, such data is important to foster data processing and reliable evidence-based decision making in Sub-Saharan Africa (SSA). In this presentation, we highlight the provision of freely available data on land cover, land use, environmental hazards, and pressures, and on demographic and socio-economic information. This knowledge is so important because in most parts of SSA, critical landscape and environmental information is often sparse, and certainly not suitable for complex analyses. Available geodata often cover the four dimensions of big data: the large volume, recurrence (temporal resolution), variety and veracity. Publicly available geodata play a crucial role in developing resilient cities especially in regions with smaller urban planning budgets. These datasets can be classified by different means for instance by their format, extent and coverage, a brief description, and relevant categories inherent in the available dataset. We categorise important openly available global and continental scale datasets into four groups: (i) Land cover; (ii) Urban land use; (iii) Environmental pressures; and (iv) Demographic information. Nevertheless, deficits must also be named: the use of Earth Observation (EO) data in circumstances where high resolution publicly available data is needed but not provided, such as to monitor sudden flash floods or varying intensities of urban heat islands and their effects on local people. To conclude, publicly available and big data in SSA has been hampered by the disparate nature of these datasets with no comprehensive overview of where and how to access these datasets. We have developed a platform to create transparency and accessibility to Open and Big Data in SSA.
Keywords: Big data; urban land use; demographic information; climate resilience; Sub-Saharan Africa

Applying An Entropy and TOPSIS Derived Water Quality Index to Assess the Levels of Anthropogenic Stress in A Wetland Complex of Ichhamati Floodplains, Eastern India
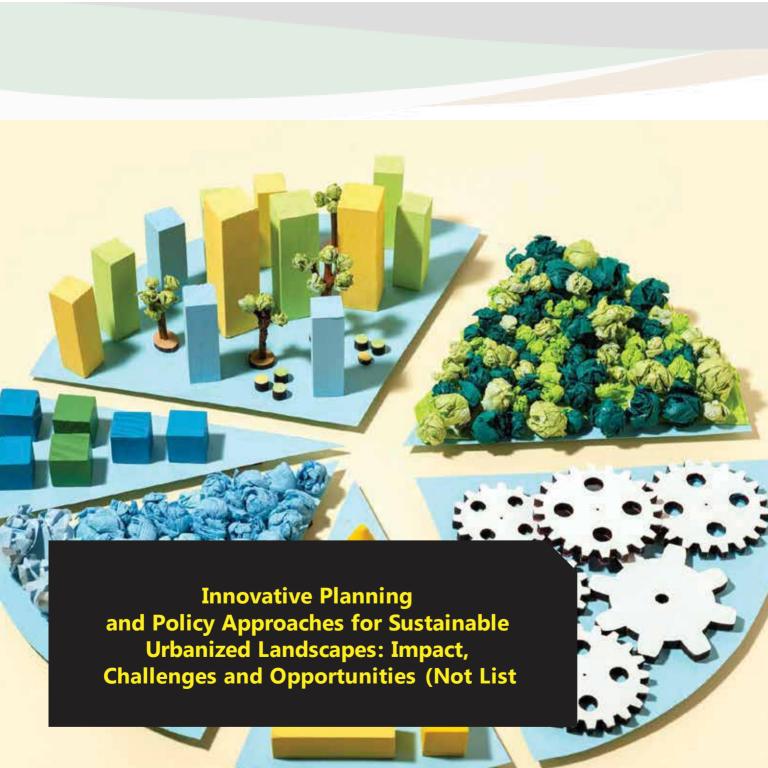
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Unsustainable anthropogenic activities put immense environmental pressure on wetland habitat condition in developing countries. In many sites, wetland water gets contaminated by various chemical compounds through agricultural runoff, wastewater effluent, jute-retting, dumping of solid waste, washing and bathing, and sanitary activities etc. In this backdrop, an attempt has been taken to make an assessment of surface water quality of seven wetlands of Ichhamati floodplains, a transboundary river between India and Bangladesh. These wetlands together

form a wetland complex based on hydrological connectivity. Water samples were collected from these wetlands between April, 2016 and April, 2022 and, successively, twelve physiochemical and biological parameters such as temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), nitrate (NO3-), phosphate (PO_4^{3-}), Ca++, Mg++, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD) and fecal coliform were tested either in field or in the laboratory. The amount of human induced pressure was estimated by setting a water quality index (WQI) having 8 criteria and 38 indicators based on entropy weighing method (EWM) and technique for order preference by similarity to ideal solution (TOPSIS) model. Thereafter, the wetlands were classified according to their WQI scores. The results revealed that anthropogenic pressure is maximum at Panchpota and minimum at Madhabpur wetlands both in 2016 and 2022. However, most of the wetlands were demonstrating poor water quality, i.e. WQI ≤ 0.40, in general. Status of agriculture dominated Aromdanga wetland has mostly deteriorated during the assessment years and was recommended as unsuitable for drinking purposes. Overall, the developed WQI was found to be a useful technique for monitoring spatiotemporal variability of wetland water quality towards attaining better environmental management.

**Innovative Planning
and Policy Approaches for Sustainable
Urbanized Landscapes: Impact,
Challenges and Opportunities (Not List**

Conflicting Interests Between Local Governments and the European Target of No Net Land Take

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To halt land take in Europe, the European Union set a "no net land take by 2050" target in 2011. However, land take continues to occur in European countries, with recent studies suggesting that local decision-making is playing a major role in these land-use conversions. In this study, we investigated how urban growth boundaries (UGBs) are used by local governments to manage urban growth in Romania. A mixed-method approach was adopted, combining analysis of UGB changes over the past decade in all Romanian cities (N = 319) with a survey among representatives of local governments involved in land-use decision-making (N = 91 cities). The results showed that many cities have expanded their UGBs, even in municipalities with population loss and sufficient undeveloped land within their UGBs, showing that local government decisions conflict with policy targets at the European level. We show that population dynamics and the extent of nature conservation areas significantly contribute to UGB changes, though these explain just a small fraction of all UGB changes. Furthermore, we identified a wide range of motivations among decision-makers regarding changing UGBs, including not only the fiscal system but also cities' competitiveness and decisions about the long-term vision for development. We argue that policy innovations in urban containment should (i) aim to balance the interests of governments at different administrative levels, (ii) account for the particularities of each state member's planning system, and (iii) allow for strategic city planning.

Keywords: urban development, land-use change, urban growth boundaries, strategic spatial planning, institutional drivers, Romania

Effects of Land Use and Landscape Position on Soil Properties in Dire Watershed, Central Highlands of Ethiopia

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Understanding soil qualities related to land use and landscape positions is critical for designing long term soil management practices in the study area. Hence, this research was set out with the objective of analysing the effect of land use and landscape positions on selected

soil physicochemical properties in Dire watershed, central highland Ethiopia. Replicated 27 composite surface soil samples were collected across three landscape positions from three land use types, and analyzed using standard protocols. Results showed that land use type, altitude and slope significantly affect important soil physicochemical properties. These include particle size distribution, bulk density electrical conductivity, soil pH, available water content, permanent wilting point, field capacity, soil organic carbon, total Nitrogen and available phosphorus. Analysis of variance results showed that significant ($p < 0.05$) effect of slope, land use, landscape position and their interaction on AP, SOM, SOC, PWP and AWC. Results of correlation analysis showed that OC, and EC have a significant positive correlation with TN but, Pav, TN, and clay content were negatively correlated with BD. Comparatively cultivated land recorded lower soil quality than forest and grazing lands.

Keywords: Landscape position, physicochemical properties, Soil degradation, Soil quality

Managing Trees to Support Biodiversity Conservation in Cities

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One of the main issues in biodiversity conservation is the coexistence with human needs, and this aspect is exacerbated in urban areas where interaction between components of biodiversity and humans reached its peak. However, biodiversity conservation in urban areas is demanded and urgent, because of the continuous (and projected) expansion of urbanization and the need to make these places more sustainable and resilient. Trees in urban areas constitute one of the main physical and biological elements that contribute to creating the urban forest that may form, when extensive and functional, a green infrastructure that is the main support to biodiversity and ecological processes in cities. Despite their importance, the potential of trees to effectively support biodiversity and deliver ecosystem services is hampered by cultural traditional practices and by management strategies that do not incorporate conservation principles. In order to reduce this gap, it is important to focus on different criteria that influence tree management, in particular aesthetic, safety, and tree health needs and biodiversity. Here, we present a study that aims at: i) improve our knowledge about biodiversity associated with trees considering the whole community of organisms, ii) test an innovative sampling protocol, and iii) use the information derived from this study and from literature to raise awareness about the importance of tree characteristics to sustain biodiversity in cities among professionals and citizens. The results presented will be preliminary of an ongoing research project started in 2022.

Urban Greenspace for Nature, Society and Culture Across Diverse Landscapes and Contexts In Eastern Europe

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Global policies call for a transformation in society's relationship with nature and acknowledge the importance of increasing urban green space (UGS). This study explores how urban citizens' diverse values and perspectives in relation to nature could be used to develop transformative visions for urban planning. The study was conducted in five large cities with different physical landscapes and social contexts in Armenia, Georgia and Ukraine – countries of recent and ongoing armed conflicts, which impose additional burden on the provision of UGS in Eastern Europe. In total, we conducted 800 interviews, which concerned the different preferences and values that people attributed to UGS and included participatory mapping of preferred types of UGS. We used the Urban Nature Futures Framework to organise the preferences, perceptions and values that respondents attributed to different UGS along three principal axes: eco-centric intrinsic, utilitarian, and relational. By integrating qualitative and spatial information from interviews with biophysical landscape data, we identified and mapped areas in our studied cities according to three main classifications (i) UGS for Nature, areas with potentially high ecological values depending on efforts to protect, restore or sustain them; (ii) UGS for Society, areas with the potential to provide a range of benefits essential for human wellbeing; (iii) UGS for Culture, where people have opportunities to actively engage with nature in activities contributing to social cohesion, sense of place, cultural identity, and stewardship of nature. The results could provide methodological references for innovative planning of UGS as multifunctional urban green infrastructure along urban – peri-urban gradient towards sustainable urban landscape design. We discuss how this approach could transform the current planning process to co-design Nature Futures for urban areas across different contexts in Europe.

The Practice and Potential of SITES v2 Rating System for the Sustainable Design of Landscape: A Case Study of Chicago's Navy Pier

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The landscape is a synthesis of the cultural and natural processes of a place, which can be designed and maintained to be ecologically resilient and thus to be able to both improve and regenerate the natural benefits and services of ecosystems. As such, how to develop and manage our landscape will play a significant role in the health and welfare of humans in the future. The Sustainable Sites Initiative was an interdisciplinary group effort that developed a rating system that identifies and advances best practices for landscape architecture. SITES v2 Rating System was produced through a multi-year iterative process. It is presented as a systematic, comprehensive set of guidelines to incentives sustainable landscape practices by using an ecosystem services framework. Opportunities for continuing research on how SITES v2 encourages the creation of a landscape sustainability system and drive more sustainable land development to become apparent as it expands in application, scope, and impact. In this study, taking the SITES gold-certified project Navy Pier in Chicago as a case study, the authors aim to illustrate the practice and potential of SITES v2

for sustainable design of a landscape. The results show as an important tool for transformation from theory to the implementation of ecosystem services, SITES v2 is being used to guide design decisions toward sustainable outcomes. It also can promote the entire project accountable to a higher standard of best practices and result in a more sustainable site. In the context of practices of contemporary landscape architecture, SITES v2 may lead to the transformation in sustainable landscape design. Our study can promote the ongoing application of SITES v2 and the creation of a better sustainable landscape through design. It holds the potential to highlight how the methodology on which SITES has been created, can be linked with future cities development and urban landscape management. *Keywords: sustainability, Chicago's Navy Pier, SITES v2 rating system, resilience, sustainable landscape design*

Rethinking Food Security: The Role of Urban Agriculture in Shaping the Food Welfare

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Although several recent and less recent studies recognized the relevance of urban agriculture (UA) in dealing with urban food poverty, few empirical research efforts were put into understanding how UA might consist of a structural column for food welfare. The reason depends on the lack of a specific definition of "food welfare". Therefore, this research primarily intends to understand how UA may affect the constitution of a food welfare definition. Then, to provide practical and replicable knowledge, the research aims at comprehending the quantitative UA's impact on potentially- emerging food welfare in the context of the city of Turin. The methodology is composed of several parts. At first, a systematic literature review is carried out to address theoretical points of juncture among food poverty-related terms present in the literature. The connections provide the theoretical floor to define food welfare. Successively, quantitative research foresees mapping the UA actors active in the city of Turin and collecting information regarding the amount of produced food. Then, qualitative research is carried out to ascertain experts' positions regarding food welfare and the potential role of UA in food welfare strategies. The sample is selected via a purposive method to collect information from the most relevant and informed individuals. Given the innovative targets of the research, it is hard to define possible results. However, a primary definition of food welfare is expectable; moreover, broader comprehension of effective tools to challenge food poverty can be expected as well. Third, the research may provide solid knowledge for policymakers to develop not emergency-led solutions regarding food poverty. Finally, the research provides a substantial floor for future scholars' and practitioners' work.

Governing Urban Regions with a Network of Plans

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While our environment becomes increasingly urban, governance of urban regions poses multifaceted

challenges. Plans are an essential element in the governance of urban regions, with usually several plans standing in a larger context and interacting with others. There is a growing recognition that in studying the governance of urban regions requires looking beyond individual plans and examining networks of plans. Existing work on plan networks focuses on documents but neglects the agency of the people and governments who create and implement the plans. This study aims to help fill this gap by developing an analytical framework for exploring urban governance within a network of plans, focusing on alignment of plan content, plan interactions, and plan's relative efficacy. The framework was applied in the Austin, Texas region (USA), studying five strategic plans dealing with the built environments, transportation systems, and natural areas over the past 20 years. We rely on textual analysis of the plan documents to assess the first component and, to assess the latter two components, on original data collected from planning staff and stakeholders in interviews and supporting questionnaires. Our analysis shows that the framework provides a useful way to understand the workings of a network of plans in urban regions.

Implementing NbS Within Cities: The Case Study of Turin (Italy)

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The topic of Nature-based Solutions (NbS) is of growing interest in many research fields, as represent useful solutions to mitigate the negative impacts of urbanisation, attempting to partially mitigate the effects of climate change and the urban heat island phenomenon. Several European projects have funded the implementation and monitoring of NbS in urban areas in recent years. Within the EU-funded projects, special attention should be paid to the 'Productive Green Infrastructure for Post-Industrial Urban Regeneration' (proGIreg) project that promotes the urban regeneration of post-industrial areas through the implementation of NbS. In particular, our case study is the city of Turin (Italy), where seven different types of NbS have been implemented and are being monitored. Among the various aims of the project, the identification of areas where to implement or replicate NbS is needed. Among the various solutions, an insight of the urban forest (UF) as NbS is proposed. In order to identify areas of the city where to implement UF, a modification is proposed regarding the application of the 3-30-300 rule. In particular, it is suggested to apply the methodology on grid cells as a unit and not on administrative boundaries (neighborhoods), so that results can be more easily compared between different urban realities. The results highlight the areas of the city that should provide for UF as NbS interventions. A future assessment of the quality and health of public green areas could be useful to properly evaluate the ecosystem services provided and further detail the areas that need wise implementation and management of public green areas, including through NbS.

Geodesign to Support Local Planning Towards Sustainable Urban Transformation with Nature-Based Solutions in Metropolitan Regions

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Planning with nature-based solutions (NBS) has the potential to foster sustainable urban transformation, but a key requirement remains the meaningful inclusion of various legitimate interests in the planning process. Geodesign has been proposed as an effective approach for boundary management, i.e. a process that seeks to overcome real or perceived 'boundaries' between stakeholders and knowledge holders. However, there is little empirical evidence behind this claim, especially in relation to local planning with NBS for ambitious urban transformations. This study aims to i) develop and test a geodesign process to facilitate collaboration and co-creation between stakeholders involved in planning sustainable urban transformation with NBS and ii) explore the potential of geodesign for boundary management to increase the credibility, salience and legitimacy of the process. The Skarpnäck district in Stockholm, Sweden, was chosen as a case study, given the increasing demand for housing and ambitious regional and municipal targets for biodiversity and social cohesion. We applied a six-step geodesign process, including a two-day digital and interactive workshop with stakeholders. Step 1 involves jointly defining the context and understanding the challenges of the study area. Step 2 involves the development of two scenarios with different transformation ambitions, i.e. a 'Current Scenario' aligned to the Stockholm Plan and a 'Transformative NBS Scenario' that promotes greater adoption of NBS.
The next steps, i.e. suitability analysis (step 3), land-use change (step 4), impact assessment (step 5), and reflections (step 6) are covered during the two-day digital and interactive workshop, using touch-tables and a specially prepared GIS interface with CommunityViz 5.2. The results of a pilot workshop suggest that geodesign has helped facilitate boundary management, but that technological limitations can be a challenge. We provide the full results of the workshop and reflect on the main lessons learnt, also suggesting promising avenues for further research.
Keywords: ecosystem services, biodiversity, transformative change, boundary work, Stockholm

The Role of Land, Water and Energy (LWE) Nexus in The Transformation of African Women's Livelihoods: A Literature Review

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Gender equality and social inclusion (GESI) is gaining increasing attention in development discourses in recent times. The different roles and responsibilities fulfilled by women, men and youths in the society influence differential opportunities, challenges and are also affected by external threats. Most rural African women for example, dominate the domestic sector as caregivers and food providers. Opportunities available to African women may range from having some decision-making power over what to cultivate and what meal to prepare for the family. In spite of that they are faced with a catalogue of challenges including access and control over land, access to finance and inputs, access to water and energy etc. The challenges faced by African women are influenced by cultural practices, policy, perceptions about women's work, and environmental factors such as climate change. Efforts at addressing these challenges and optimizing women's work have been slow in gaining momentum. Failure to adequately articulate the gender issues affecting women's optimal performance of their gender roles may affect the rural food pipeline and consequently rural-urban food security. This research is framed on the assumption that the application of Land Water Energy (LWE) nexus approach to optimise African food system has not duly considered gender integration and transformation. The research question is therefore: how has LWE nexus contributed in influencing gender transformation in African food systems? The research objective was achieved through a literature review of African based publications on the gender approach to LWE nexus and sustainable food systems using the LWE and gender transformative framework. The identified gaps in the research includes a limitation in the research in terms of quantity and quality of publications on the gender inclusive LWE nexus thematic area. The most significant research outcome constitutes the lack of application of suitable gender inclusive LWE nexus framework in analysing and enhancing the transformation of women's role in sustainable food systems in Africa. Limited research conducted on the gender inclusivity in the LWE and sustainable food systems research implies a deficiency in research-based evidence to influence policy development and practices that will contribute to gender transformation in sustainable food systems in Africa.

Identifying Potential OECMS for Bird Conservation in Human-Dominated Areas of Beijing

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The biodiversity in areas with higher human impact is as crucial for conservation as that of protected areas. Ongoing discussions are taking place on establishing

"other effective area-based conservation measures" (OECMs) proposed by the post-2020 biodiversity framework. Inclusive conservation practices and landscape approaches in urban greenspaces are being considered for this purpose. Countries should identify suitable areas for OECMs to promote co-existence between humans and wildlife. However, there is limited research available to guide the policy-making process of identifying potential OECMs using evidence-based measures. The study develops a two-way "priority-feasibility" framework to identify priority areas for bird conservation in urban areas. The study area is Beijing, and more than 300,000 public birding recording points data are used to simulate habitat suitability with the MaxEnt model. Conservation priority is assessed by simulating extinction risk with the Zonation decision-making tool. The study identifies the priority of bird conservation in three types of potential management units: parks, campuses, and enterprise cluster areas, which can be used to conserve birds in a compatible approach. After examining 2,873 management units in Beijing, a list of 72 management units is selected as a priority for considering OECM establishment, with 53 parks/scenic areas, 5 enterprise cluster areas, and 14 campuses. These areas cover approximately 2.13% of the area of Beijing and basically encompass the range where most bird species frequently occur. It is necessary to supplement the compatible conservation network with these management units, as well as protected areas in Beijing.

The (Built)Landscape of Metropolitan Areas in South America

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Worldwide, the complex and multifaced characteristics of urban expansion contribute to increasing the challenges for policymakers in planning and managing metropolitan areas. In this work, we assessed the changes in metropolitan landscapes in South America by 1) analysing the changes in several configuration metrics of the built landscape; and 2) evaluating the correlation between the configuration metrics and several socioeconomic characteristics. Based on the global dataset from the Lincoln Institute of Land Policy, we selected the metropolitan areas located in South America (17 cities, 145 municipalities) and computed the changes in urban configuration between 1990 to 2000 and 2000 to 2015 for the following metrics: total built-up area, urban density (population/built-up), urban extent, fragmentation, compactness and types of new built-up (infilling, edge-extension, inclusion and leapfrog). We collected demographic, ethnographic and economic information and correlated them with the metrics for urban configuration. Overall patterns suggest that urban landscapes in South America are diverse and have changed during the studied period: cities are getting more saturated and slightly more compact, and this

pattern was clearer observed during the first period. However, urban density decreased in most cities, and several cities got more fragmented and/or less compact, possibly suggesting a sprawling trend. Regarding the relationships between urban configuration and socioeconomic characteristics, preliminary results suggest that cities with a higher increase in population presented a higher increase in the built-up area and compactness, a higher proportion of edge-expansion pattern and were the most saturated ones. Cities with higher HDI presented a higher increase in urban extension. The percentage of self-declared afro-descend and indigenous was correlated with more fragmented patterns, possibly suggesting racial segregation. Coupling socioeconomic information with urban configuration is crucial to supporting planning and policy instruments to transform South American cities into more inclusive and sustainable landscapes.

Keywords: Landscape configuration; landscape change; multidimensional; socioeconomic; South Globe.

Fostering the Biodiversity through a Participative Approach and Experts Support: A New Experience from Lombardy (Italy)

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EU Nature2000 network gather the protected areas with habitat and species of high conservative value in the whole UE. Lombardy (Northern Italy) hosts 246 Natura2000 sites (15% of territory). Anthropogenic pressure due to land fragmentation, pollution and invasions of alien species is endangering habitats and species, while climate change is increasing the pressure. Aiming to implement an integrated strategy for Natura2000 in Lombardy, LIFE Integrated Project GESTIRE2020 faces the main problems concerning biodiversity in one of the areas with the higher population density in Europe. In this fragile balance, IPG2020 introduces the Technical Facilitators (TFs): 20 experts with different tasks:(a) researching funding opportunities; (b) fostering the network between local and central authorities, the needs of the territories and the objectives of the institutions; (c) helping the stakeholders on drawing up biodiversity projects; (d) supporting Life Project Actions with specialists in botany, zoology, agro-economy, hydrobiology. The Life Project is ending during the current year and till now 436 projects have been drawn up for tenders focused on biodiversity conservation, involving almost 52M €, gathering public and private funds. TFs often have supported the drafting of tenders, focusing them on biodiversity conservation issues. Beyond the economic importance, therefore, this experience will have the important roles of: a) influencing the methods of disbursement of funds for a better efficiency in the safeguard of biodiversity; b) showing that biodiversity can be a transversal theme, since public administrations have had professional figures at their disposal able to assist them in the governance of biodiversity conservation issues. This experience can easily be

replicated into similar regions, adapting it to the individual territorial and administrative conditions.

New Standards for Climate Change Adaption in Planning Competitions in Germany? An Approach with Assessment Criteria

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The research project "Green City of the Future" aims to investigate the integration of green infrastructure for climate adaptation into urban planning procedures in dense and growing cities. One of the working packages of this project examines how green and blue infrastructure can be secured in urban areas and what instruments can be used during different planning phases. To address this question, the project analyses planning competitions using a combination of process analysis, interviews and group discussions in real-world laboratories to develop assessment criteria for climate adaptation. The goal is to provide a framework for integrating climate adaptation into planning competitions, which can ultimately help create more sustainable and resilient cities. The project's emphasis on green infrastructure and its integration into the planning process offers a promising pathway towards climate adaptation and resilience in urban areas. By examining the use of planning competitions as a tool for promoting sustainable design, the study offers practical recommendations for city planners, policymakers, and designers to create more livable and environmentally-friendly urban environments. The study also explores the challenges and opportunities associated with implementing such criteria in the competition process, emphasizing the importance of engaging stakeholders in the planning process to ensure that their perspectives and needs are considered.The findings of this research project can provide valuable guidance for urban planners, designers, and policymakers who want to promote sustainable and resilient cities. Ultimately, the research seeks to inform a more holistic approach to urban planning that prioritizes the needs of both residents and the natural environment, which can lead to more livable and healthy cities for all.

Public Urban Green Infrastructure Equity for Cooling off from Extreme Heat in Bochum, Germany: Insights from a Public Participation Geographic Information System (PPGIS) Survey

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Extreme heat in urban areas is projected to increase due to climate change. Characteristics of individuals and groups can increase vulnerability, the spatial consideration of which is needed for promoting equitable and environmentally just adaptation. Urban green infrastructure (UGI), a type of nature-based solution (NbS), can reduce temperatures in cities (e.g., through mitigation of the urban heat island effect) and provide cooling oases for local citizens on hot days. UGI and associated benefits may have varying degrees of

availability, access, and quality within different neighborhoods and for different people. In addition, individual preferences and values can influence why people visit or avoid certain UGI, and characteristics such as shade, air movement (breeze), and the presence of water can both reduce temperatures and attract users. Thus, to effectively plan environmentally just UGI, it is necessary to understand how it is being (under)used, by whom, and why. We use the public participation geographic information system (PPGIS) platform (MaptionnaireTM) to conduct a survey (closed 28.02.23) exploring UGI use in relation to extreme heat among residents of Bochum, Germany. We are guided by three research questions i) To what degree do different residents rely on UGI to reduce exposure to extreme heat?; ii) What places within the UGI are preferred for visiting to cool off during extreme heat?; and iii) What characteristics of UGI are visitors most satisfied with for cooling off during extreme heat? We conduct spatial and statistical analyses and assess environmental justice by comparing satisfaction of UGI characteristics with an index of social vulnerability, perceived heat risk, and residential location of respondents. Our findings can inform the environmentally just adaptation planning of UGI in Bochum and provide a methodological template for researchers and other global cities facing extreme heat.

Planning A Just Distribution of Benefits by Mitigation Measures for Flooding Risk

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The issue of spatial equity of Nature-Based Solutions in cities generally concerns the spatial distribution of their benefits to local residents and other city users. In the context of flood risk management, planners are challenged by the identification of effective mitigation and adaptation measures that can generate benefits to the higher number of people and, more specifically, to people with highest levels of exposure and vulnerability. To address this issue, an essential step is to identify the geography of needs for mitigation, intended as prior areas where to locate measures for flood risk mitigation. This study combines geospatial layers of multiple dimensions of exposure and vulnerability to flooding and identifies prior areas where to design scenarios for mitigation flooding risk, for a regional case study located in Sicily. Results show patterns of exposure and vulnerability that vary according to locally relevant physical and social urban dimensions. Based on results, proposals for mitigation actions are advanced with the overall objective of generating equal benefits to the most vulnerable exposed social subjects. Moreover, this study argues on particular implications of implementing stormwater green infrastructure planning for equal beneficial distribution of the potentially achievable risk reduction.

Assessing the Relationship Between Urban Form and Liveability Under a Planning Perspective

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The spatially explicit urban form affects the quality of life at cities. That is why many planning measures aim to optimise the built environment for people's health and well-being. The increasing availability of high-resolution socio-economic and 3-D building data is promising for analysing the relationship between urban form and liveability and is therefore of interest for urban planning. Accordingly, this study aims to assess these relationships at neighbourhood scale, using the city of Zaragoza (Spain) as an example. First, we analyzed the spatial distribution of social characteristics, namely 'age', 'sex', 'birthplace', 'marital status', and 'education' within the city by means of the location coefficient to assess social segregation. We then grouped neighbourhoods according to their levels of social characteristics and described their urban form types and planning history. Furthermore, we assessed the relationships between social characteristics of residents and the urban form of their place of residence using regression analysis. Preliminary results show that in neighbourhoods that have grown due to rural migration in the 1960's and 1970's, an older population with low education levels and greater cultural heterogeneity is concentrated. These neighbourhoods are mainly characterized by compact and open mid-rise morphologies. On the other hand, the city center and neighbourhoods developed along the south expansion of the city concentrate a population with higher level of education and a greater diversity of ages, where morphology shows a higher variation from compact or open high-rise forms to sparsely built-up areas in the city outskirts. The study constitutes a first-step to provide valuable information for supporting planners and policy makers at neighbourhood scale for sustainable development of urban areas.

Keywords: Urban morphology, social variables, spatial metrics, quality of life

Demand and Supply of Ecosystem Services in an Urban Landscape of Guatemala

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Urban ecosystem services are paramount for quality of urban life. Around the planet as urbanization takes more agricultural and forested land, it is becoming important to understand how to improve urban green from protecting existing natural vegetation or creation of new green spaces. Guatemala City has been growing into a metropolitan area since the 1970's. Recently, is experiencing both vertical and sprawl urban growth. These urban landscape changes have been jeopardizing existing natural and cultural urban vegetation and the

pace in which urban green spaces are created is not enough to compensate.

Where the provision occurs? and where the demand is? turns into a key element for ecological sustainability and urban planning for the city. Analysis of ecosystem services in Guatemala City municipal boundaries was done to understand their spatial patterns. Therefore, we conducted modeling of Water recharge, Air pollution removal, Erosion control, Recreation and Temperature regulation as ecosystem services. They were spatially explicit supply and demand models. Supply was mainly based on urban green elements and demand on recent population counts. Modeling of urban ecosystem services included SWAT model for water recharge, RUSLE model for erosion control, network analysis for recreation, geographic regression for Temperature Regulation and iTree Eco for air pollution removal. Results show there are spatial matches and mismatches which consequently have implications for urban planning. Some districts lack ES provision for its demand, in that sense, some solutions are discussed and suggest to implement at the neighborhood level.

Smart Urban Solutions Resulting from Flood Risk Assessment

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Based on the rainfall-runoff model of the territory in three scenarios, the flood threat in the urban environment is solved. The scenario modelling procedure using FLO-2D and HEC-RAS software is intended for risk prediction resulting from climate change and the design of smart solutions in the urban environment. The procedure concluded with the proposal of measures to reduce the size of the flood threat in the city and the flood risk is intended to increase of city resilience and sustainability of the urban area in terms of new modes of planning and innovative spatial planning.

Understanding Social-Ecological Sustainability of Urban Landscape, From a Prospective of Urban Parks' Health Benefits in Beijing,China

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The rapid urbanization with consequent land-use change and ecosystem degradation have caused various environmental problems, and lead to the progressive separation of urban residents from nature. Faced with enormous challenges on public health, urban green space planning interventions have emerged as an important issue and nature-based solution for sustainable development of cities, especially in high-density urban areas. However, few studies have focused on the role of urban parks in affecting health outcomes and the differences among population groups.

Considering the area proportion of total green spaces and urban parks within different spatial scales, and different urban park distribution characteristics including availability, accessibility, and attractiveness, this study attempted to understand the associations between urban parks and self-reported health of urban residents, and to identify the variation among population groups. Based on a series of spatial explicit assessment and multi-regression analyses, results showed that the area proportion of urban park was more significant than that of total green spaces in affecting health outcomes, no matter in neighborhood or sub-district scales. Among various dimensions of urban park distribution characteristics, accessibility was found to have more significant impacts on health outcomes than availability and attractiveness of urban parks, especially for the elderly group. To create healthy and equitable settlements, these findings suggested that planners and managers should give urban parks extra priority in green space decision-making, and provide more conveniences for the vulnerable groups to access parks. Further research into exploring the assessment of different planning-related urban park distribution characteristics, and associations between different urban park types and health outcome could provide more exact and practical information for planners and managers.

Keywords: Urban green space; Spatial pattern; Self-reported health; Vulnerable groups; Social equality.

Projecting Future Impervious Fraction in Urban Landscapes Under Alternative Socioeconomic and Climate Scenarios with Implications for Water Resources

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The fraction of impervious cover on developed land has important implications for ecological resilience in urban landscapes because the provision of ecosystem services, including water quality and quantity, depends on land cover type and condition. As income and population grow and urban land use expands, so too will the amount of impervious surface. However, the degree to which new development will add impervious cover and how that impacts water provision remains uncertain. In this study we examined how future scenarios of development, driven by population, income, and climate projections, affect the imperviousness of urban landscapes at the small watershed scale across the conterminous United States (U.S.). Using empirical model estimates we project future impervious cover for 20 alternative climate and socioeconomic futures for combinations of two radiative forcings (RCPs) and four socioeconomic pathways (SSPs). Total impervious area is projected to increase through 2070 under all scenarios; however, SSPs with relatively higher rates of socioeconomic change led to greater projected increases in average impervious fraction. Projections for average impervious fraction on developed land in 2070 range from 29.6% (2% decrease compared with 2020) under climate models in the low-growth SSP scenario to 34.2-34.6% under a high-growth SSP scenario (15% increase), and a total increase in impervious area of

53,700 to 84,400 km2 (50-78% increase) compared to 2020. We also find notable regional differences where average impervious fraction is projected to decrease in the Pacific Coast region of the western U.S. under all scenarios, suggesting that new development will be less impervious than the current average. We demonstrate application of our results by identifying watersheds where impervious cover could exceed thresholds for water quality and aquatic biological integrity. We discuss implications for sustainability of urban landscapes and the ecosystem services they provide.

Meta-Analyses of the Ecological Effects of Urban Form: Sprawl Versus Compact Residential Development

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Population growth within cities and the expansion of urban residential development are among the fastest growing and least reversible drivers of global land use and land cover change. A central issue in the management of these impacts is the role of urban form. Here, we report the results of the first quantitative synthesis of the ecological effects of urban form. We systematically searched the literature to identify studies that either empirically compared ecological responses in existing compact and dispersed developments or modeled the projected impacts of urban form using development scenarios. For empirical studies, we calculated a positive overall effect (g) of 0.23 (95% CI: 0.21-0.25), indicating that compact development is associated with more positive ecological outcomes than dispersed development. The best model of the effects of moderator variables on empirical study effect sizes showed that ecological responses were more positive in compact developments only when urban form extent was large and investigators measured habitat amount or biomass. For modeling studies, the overall effect was also positive, although weaker (L = 0.02 (95% CI: 0.01-0.03)). The best models of the effects of moderator variables on modeling study effect sizes included latitude, biome, and urban form extent, which, when accounted for, resulted in non-significant overall effects of urban form as measured by model intercepts. We conclude from our results that 1) the effects of urban form depend on spatial scale and ecological response measure and 2) that heterogeneity among studies published to date precludes an easy answer to the urban land sparing/land sharing debate. Local studies in individual municipalities are needed to bolster the power of future syntheses and to provide planners and managers with contextual evidence supporting one urban form approach over another.

Research on identification and Management planning of Other Effective Area-based Conservation Measures around Wuyi Mountain National Park

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Other Effective Area-based Conservation Measures (OECMS have great potential to enhance ecosystem connectivity and protect key biodiversity areas (KBAs), however less than 1%of the world's land and freshwater environment are currently covered under this designation. And until now China has not carried out OECMs as protect areas designation tools. How OECMS can be used in China to increase the area of protected areas is crucial way to achieving the CBD target of conserve 30%of the planet by 2030. Research compares the OECMs that have been implemented internationally in the past ten years, Quantitative OECMs identification index combined with China's national conditions. And takes the surrounding area of Wuyi Mountain National Park as an example to identify potential OECMs. Regional value judgment and space definition of OECMs are carried out, and summarizing their protection and development modes. Based on spatial analysis of OECMS. the management plan around Wuyi Mountain National Park are established to strengthen the connectivity and integrity of regional ecological corridors, and achieve the goal of biodiversity conservation.

Importance Of Urban Green Spaces Conservation in Providing Ecosystem Services and Climate Change Mitigation in Developing Countries

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Urban green spaces (urban forests, urban parks, garden parks, sacred forests, roadside trees...) throughout their conservation play a high role in human well-being and welfare by mitigating climate effects. This is because of their capacity to exchange solar radiation from the sun that is transformed in CO_2 to freezing and fresh air fulfills of oxygen. These urban green spaces help with land conservation and stability and also with climate amelioration. Ecosystem services provided by urban green spaces are vital for humans in urban regions. Large and contiguous core nature areas, smaller green areas and ecological connections between them are the essence of regional ecological networks and are essential for maintaining interconnected habitats for species and thus biological diversity. Thus, both local and regional level ecological networks are vital for maintaining ecosystem services in urban regions. However, urban development through urbanization poses a great problem for the ability of urban green spaces to be conserved. The expansion of urban cities has resulted in the fragmentation of urban green spaces from rural green area. This phenomenon is still ongoing toward the cities. In that case, it is almost impossible for human to benefit of ecosystems services provided by urban green spaces. The impacts of climate change coupled with land-use and land cover change will bring serious challenges for maintaining urban green spaces and thus ecosystem services in urban areas. Indeed, despite its importance, urban green spaces faced a numerous pressure from those it protects. A numerous of people do not care about the benefit resulting of urban green spaces. This because there is a lack of information on ecosystem services of urban regions and there is a need to enhance the knowledge for cities

development planning. The results of this project will help decision-makers and populations to take a good conservation strategy plan into the urbanization process with the purpose of climate adaptation and mitigation.

Preparing for the EU-Nature restoration law to restore ecosystems

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The EU-biodiversity strategy 2030 demands improvement of the Trans-European Nature Network TEN-N and an improved conservation status of species and habitats of the Directives. The more recently proposed EU-Nature Restoration Law (June 2022) requests action to restore at least 20% of degraded ecosystems by 2030. The law will be legally binding and has large implications for all EU-Member States and conservation organisations. There is a huge task ahead for all Member States to prepare nature restoration plans, within two years of adoption of the Nature Restoration Law.

We assess the possibilities for nature restoration, what measures are feasible and how to choose best options. The focus is in particular on forests and grassland ecosystem. For two transboundary areas, landscapes straddling the Dutch-German border and Dutch-Flanders border, is assessed: what habitat types are most degraded or under pressure by climate change. Possible restoration measures are adaptation of forest composition, creating forest corridors, planting of hedgerows or agroforestry. For grassland restoration

opportunities are in diversification of grasslands, extensification of management or grazing. With models like LARCH, DIMO and QuickSCAN we assess the impact of measures to restore habitats and species and to improve the TEN-N, impact on biodiversity, connectivity, productive functions for farming and forestry. The restoration options will be used for discussion with stakeholders, to assess their preferences and adjust them where necessary. More important than two regional restoration plans is the resulting methodology, tested in preparation for the EU-Nature Restoration law. Countries preparing for the Nature Restoration Law can learn from this project how to develop nature restoration plans, lessons which extend to all countries.

Keywords: Conservation; Restoration; EU-legislation; Nature Restoration Law; forest; grassland; transboundary

Key Messages from Global South Landscapes: Challenges and Opportunities in Research from Africa and Latin America Regions

Key Messages from Global South Landscapes: Challenges and Opportunities in Research from Africa and Latin America Regions

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Global South countries in Africa and Latin America (LATAM) refer to those underdeveloped or economically disadvantaged countries. These nations seek to solve similar challenges such as poverty, population growth, disease, and deforestation. In this symposium we aim to (i) identify the mutual and region-specific challenges in terms of research from a landscape ecology perspective, (ii) identify future trends in research under global change scenarios, and (iii) explore opportunities of south-south collaboration to cope with ecological, human and climate crisis. Through a preliminary systematic review in landscape journals, we found 388 and 339 articles (Web of Science) conducted in LATAM and African landscapes respectively between 1981 and 2023. Overall, cities and forests are among the most studied landscapes in LATAM and Africa. However, articles from Africa exhibit a wider field of research including social-ecological systems, sustainable solutions, and green infrastructure. In LATAM, changes and management in Amazon Forest landscapes and studies related to animal ecology and remote sensing represent an active research field. Authors from Brazil are involved in 35% of the LATAM articles, followed by USA with 25%, Mexico 12% and England (6%). A similar trend is observed in African studies, in which South African authors are involved in 31% of the articles, followed by authors from USA (27%) and England (10%). In both regions, landscape research is concentrated in very few countries. Surprisingly, 42% and 43% of the articles are led by researchers affiliated to LATAM and African organizations respectively. We anticipate that future LATAM-Africa collaborative landscape ecology research will provide relevant scientific evidence to support decision making in both regions. During the symposium, we expect to deepen these results and to propose key messages for the international IALE community.

Impacts Of Atlantic Forest Landscapes Homogenization on Amphibians and Birds

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Land use intensification has homogenized landscapes across the tropics, potentially causing additional biodiversity reductions and simplifications, which could further compromise ecosystem functioning and services. Here we evaluate amphibian and bird diversity in 89 landscapes with 16km² each, ranging from 5-100% of native habitat, with landscape heterogeneity, measured based on types of land use, distributed in below, above and between one standard deviation of the mean heterogeneity for every evaluated percentage of native habitat in the fragmented landscapes.

Biodiversity samples were taken based on automated audio recorders, which recorded one minute every ten minutes, along at least 3 weeks in each landscape, totalling 433,436 minutes. Species were identified based on simple pattern matching algorithms in the Arbimon platform. Currently we have 230 identified species. Our preliminary results showed that both, birds and amphibians species richness and composition changed along the habitat amount and diversity gradients. Species numbers increase with habitat amount and for fragmented landscapes, landscape heterogeneity influences differently along the habitat amount gradient. High diversity landscapes presented disproportionally more species in higher habitat amounts, whereas intermediate diversity in intermediate amounts. The most marked changes happened between the pristine continuous forests and the fragmented landscapes, which even with high amounts of habitat (~70%) presented a lower number of species. Moreover, edge or low sensitive species were found mostly in lower amounts of habitat, while more specialized species, such as marsupial frogs (eggs develop in or on the body of one of the parents), were restricted to higher amounts of habitat. Changes in functional groups were seen in birds, and amphibians presented losses in reproductive modes, also potentially affecting functional diversity. Our results suggest that landscape heterogeneity played a key role in sustaining biodiversity, and landscape homogenization could further impact biodiversity, ecosystem functioning and services, even without reducing habitat amount.

Urban Nature: A Biocultural Diversity Perspective from Latin America

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The concept of biocultural homogenization describes the global phenomenon where the standardization of concepts, ideas, and habits is closely related to the biological homogenization of habitats, ecosystems, and landscapes (Rozzi et al, 2019). This phenomenon is particularly relevant to explore in urban ecosystems because the exposure to similar nature in different cities may lead to the homogenization of people's values and perceptions, potentially resulting in a low diversity of urban habitats.

While frameworks, such as nature-based solutions developed in the Global North, may help to address socio-environmental challenges in Latin American cities, their use should not threaten existing biocultural diversity. Community initiatives dealing with urban nature in Latin America seem to resist homogenization. We hypothesise that this resistance occurs because communities seek to preserve urban biocultural diversity.This work presents examples of community initiatives in Latin American cities to illustrate the existing urban biocultural diversity and their role in its preservation, reflecting on the potential contribution of this region to the international debate on the subject. The results show that modern community initiatives are resignifying ancestral values and perceptions about nature, linked to alternative visions such as "buen vivir," "candomblé," and notions of "pachamama." These initiatives are strongly linked to traditional practices such as "minga" and the protection of native medicinal and sacred plants.

Finally, from a decolonial perspective, it is essential to recognize and mitigate the different types and scales of oppression that promote biocultural homogenization to allow these community initiatives to play a role in biocultural conservation in Latin America.

Green Infrastructure Planning Principles for Land Development Applications in the City of Tshwane: Challenges, Opportunities and Future Research Areas

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Globally researchers concur that GI has the potential to contribute to the development of inclusive, safe and sustainable cities. However, GI's opportunities in SAA are often overshadowed by socio-economic urgencies and political agendas. Our study considers the challenges and opportunities the City of Tshwane officials face with enforcing minimum public open space requirements. The study co-developed a context-specific definition for GI and a suite of GI planning guiding principles applicable to the City of Tshwane. The GI guiding principles developed specifically for a Global South context are the first of their kind and aim to provide city officials, developers, and built-environment practitioners with guidance for increased GI benefits in local developments. The study identified entry points for GI guiding principles in the city's spatial planning documents hierarchy to ensure uptake and application. Eight recommendations for future research are offered: (1) Finding creative alternatives for private sector open space provisioning in urban developments; (2) Investigating alternatives of calculating and applying minimum public open space ratios for different densities and development scenarios; (3) Considering the real meaning of "equitable access" for environmental and social justice; (4) GI principles for the urban edge, considering peri-urban and adjacent rural counterparts to support anticipatory planning pursuits; (4) Understanding the perceptions, values, and preferences of local users for co-design and development of GI to enable co-ownership and management; (5) Investigate strategies to create and enhance cross-sectoral partnerships; (6) context-specific research with case-study evidence for the economic valuation of GI to bridge the green-value gap amongst different role players and stakeholders. We conclude that GI planning needs an increased focus on process and management for long-term sustainable development in the Global South.
Keywords: landscape design, guidelines, co-development, South Africa, green space, future research, Global South

Resilience Academy – A Transformative Approach for Climate Resilient African Landscapes in The Nexus of Open Data, Disruptive Technologies and Community Approaches
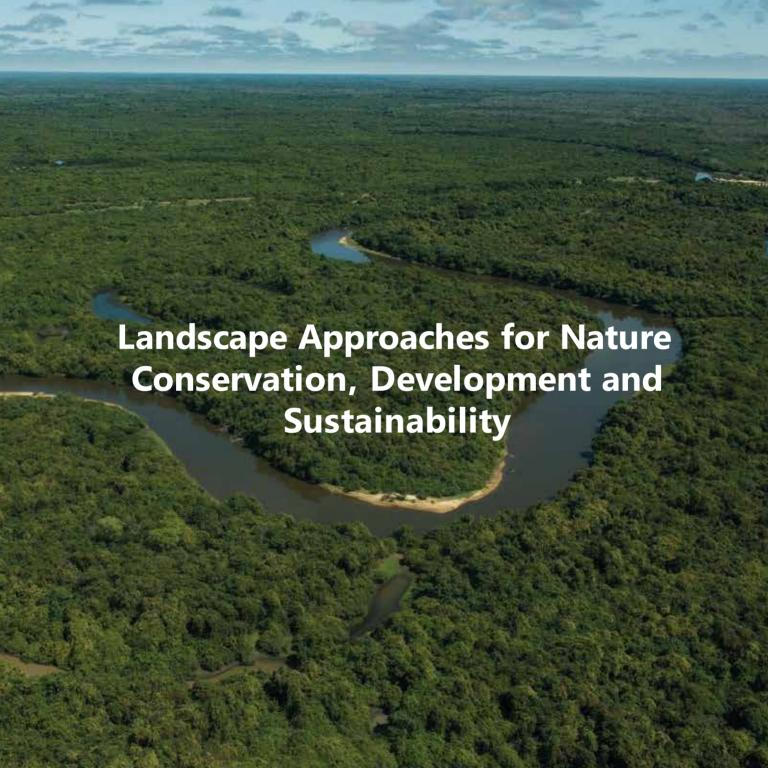
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African landscapes are increasingly vulnerable to the impacts of climate change. Rapid and uncontrolled urbanisation, degradation of natural resources and loss of biodiversity combined with scarcity of up-to-date digital information and overcomplexity of current solutions are barriers to transformation. At the same time, the digital revolution and the skills and motivations of youths in Africa are key opportunities that could accelerate deployment of landscape services for improved climate resilience. Transformation can happen if nature-based landscape solutions are simple, affordable, locally produced and scalable. Resilience Academy (RA) is a university-driven partnership model, which aims to improve climate resilience in Africa though co-creation of demand-driven, locally sustainable and scalable climate services operating in the nexus of the digital revolution, community engagement and local youth skills. It is an action-oriented and collaborative ecosystem, which thrives from open data, affordable technologies, skills development and inclusive participation of multiple actors. It builds particularly on the talent and commitment of citizens and young generation scientists to change the ways our landscapes and living environments are mapped, designed and managed for the future. Presentation engages African and European landscape and geospatial scientists to think novel and actionable ways of managing African landscape challenges through combined value of citizen and student engagement, open data, earth observation, disruptive technologies and AI. What are the success factors and challenges, and what is the role of 21st century landscape ecology and landscape approaches in managing climate and biodiversity crises of Africa? The session will challenge the audience to think how nature-based solutions can truly become locally owned, impactful and sustainable and what other issues should happen in a society for such digital landscape innovations to form and scale across the continent.

Keywords: geospatial data, Earth observation, AI, digital technologies, community mapping, socio-ecological systems, nature-based solutions, biodiversity, well-being, climate action

Landscape Approaches for Nature Conservation, Development and Sustainability

Using National Biodiversity and Strategic Action Plan (NBSAP) Framework for Promoting Regional Cooperation for Biodiversity Conservation in South Asia

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South Asia is known for its rich genetic resources and biodiversity hotspots. Some of the biodiversity unique ecosystem found in this region includes, Himalayan Landscape, Manas Conservation Area, Terai Arc, Kailash sacred landscape, Sundarbans mangrove and Bay of Bengal marine ecosystems. NBSAPs are key strategic documents that outline country-level strategies and actions for conserving, sustainably using, and equitably sharing the benefits of biodiversity. We analyzed the NBSAPs of four South Asian countries – India, Nepal, Bangladesh and Bhutan – for identifying potential actions that could promote regional cooperation amongst these countries, as all countries share biodiversity rich international borders, amongst themselves. Conservation actions can be aligned for mutual benefits. Our analysis of the four NBSAPs reveal that countries can take actions under four thematic areas, which have high potential for generating conservation outcomes, as also, generate other co-benefit, such as, increased livelihood opportunities for local communities, improved regional capacity for biodiversity management and better control of illegal trade in wildlife. These four thematic areas are: (1) Conservation of Biodiversity in the Transboundary Ecosystems; (2) Conservation of Wildlife and Protected Areas; (3) Aligning NBSAPs with Kunming-Montreal Global Biodiversity Framework; and (4) Regional Capacity Building and Knowledge Transfer. Some of the conservation actions will help adopt a landscape-based approach for ecological security and economic planning and link biodiversity with climate resilience and adaptation. We find that some of the existing legal/policy instruments already in place, for example, the Memorandum of Understanding on Sundarbans between India and Bangladesh could be effectively used to achieve conservation goals and expand coverage of Other Area Based Effective Conservation Measures (OECMs).

Transboundary Communities-Perceptions on the Relation of the Governance of The Protected Area and Local Livelihoods in the Great Limpopo Transfrontier Park's (GLTP)

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Historical socio-political events in Africa have shaped the development and management of several protected areas. Whilst conservation areas have a primary mandate for biodiversity conservation, newer concepts of protected areas (e.g., Transboundary protected areas, Peace parks) broaden their perspective, integrating social-ecological aspects, community livability and biodiversity conservation in their goals. While community livability and livelihoods play a role on the local level, participatory practices and engaging with

local communities and acknowledging their perspectives remains on a moderate level.

Poverty, limited access to resources, inadequate infrastructure, and exclusion from decision-making processes are among the main issues that affect the lives of many communities within transboundary conservation areas. With reference to the Great Limpopo Transfrontier Conservation area (GLTFCA), these challenges have been known to cause conflicts around land use, resource allocation, and economic opportunities. Despite some communities benefiting from the GLTFCA's conservation efforts and ecotourism, there is still need for continued efforts to address the challenges in participatory approaches for policy development. This study addresses this gap by investigating community perspectives on various policy documents on the park strategic frameworks that govern the protected transboundary landscapes. The study is based on Q-study, that was carried out in local communities based in Zimbabwe, South Africa and Mozambique, all belonging to the GLTFCA. It aims to assess (i) different perspective of community livelihood in relation to park objectives, (ii) whether perspectives are community distinctive or spread across communities in different countries, (ii) conflicting perspectives and opinions that might impact the governance and management of the protected area and achieving the park's objectives. Preliminary results identify 6 different viewpoints that highlight priority concerns of community individuals on park policies. These viewpoints indicate that the aspects that participants consider important for their local livelihoods are influenced by various factors which are tied to demography and location.

Gliders in the Forest: How Increasing Knowledge About a Threatened Arboreal Marsupial is Changing Forest Conservation in Southeastern Australia

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Southeastern Australian Eucalyptus forests are some of the tallest and most complex temperate forests in the world. While parts are under continuous protection in a network of parks and reserves, large areas are also subject to forest management, including timber harvesting. Additional threats arise from forest fires that are increasing in frequency and severity with climate change. These forests are home to a range of mature forest dependent fauna, including some specialists such as iconic koalas and the lesser-known greater glider. Due to distinct scale-dependent habitat requirements, species such as the greater glider are shaping forest conservation in the region today. At a landscape scale, the narrow thermotolerance of greater gliders drives their distribution to cooler and wetter forests or higher elevation, which require large scale protection from disturbance to act as climatic refugia under climate change. At a stand and local scale, the need for tree hollows for nesting and a preference for nitrogen-rich tree foliage causes greater glider distribution to vary locally, even in otherwise climatically suitable habitat. We found climate change to be the major driver of distribution and decline at a landscape scale, which has implications for reserve design. At finer scales, mature tree species composition, as well as distinct spatial patterns in stand structure determine where greater

gliders form local populations, which affects how forests are managed at operational scales. The unprecedented Black Summer bushfires 2019/20 have severely affected forest dependent fauna in the region and resulted in increased funding and research to better understand and protect species such as the greater glider. Our research focus now lies on how and why fire affected landscapes can be used by these mature forest dependent species and what implications the landscape-scale disturbance event had on smaller scale habitat resources and populations and their management and conservation.

Ecosystem Service Conflicts through the Prisms of Landscape Ecology

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Ecosystems provide a variety of utility values, benefits, and other necessary services for human life, such as climate and water circle regulation, soil preservation, and cultural value. These benefits and utility functions have recently been labeled as ecosystem services. At the same time, and despite all of these benefits, ecosystems are constantly endangered by human activity, lack adequate protection, and are regularly degraded and destroyed. The aim of this paper is to present methods for reconciling the natural values of the research area, as well as to evaluate the ecosystem service potential – using the concept of the geosystem approach to the landscape. The mutual harmonisation of two landscape subsystems – natural and socio-economic – is a decisive aspect of this approach. This requires detailed research on landscape in all of its core dimensions (social, economic, and environmental), as well as the exploration of links and relationships between them. As a result, we proposed eco-stabilization management approaches. The results of the assessment of ecosystem services in the research region may be used as background, arguments, and criteria for planning ecologically appropriate landscape and natural resource organization, management, and protection. The methodological approaches were tested on a model region of Rye Island, Middle Europe's largest drinking water reservoir. Despite intense farming and urbanization, there are still fragments of high-value natural landscapes. The clear objective of society is to find the most effective technique to protect high-quality water supplies while also utilizing bio-productivity of extremely precious soil, and to maintain a high-quality environment for the human population.

Transboundary Connectivity Conservation is Important for Species' Range Shifts in Response to Climate Change on the Roof of the World

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Species are shifting their ranges to track suitable climate conditions in response to climate change, but the rate of climate change and habitat fragmentation may prevent species from shifting their ranges. In this context, the concept of climate connectivity has been proposed by scholars in recent years, which can be

defined as the ability of a landscape to promote species movement when responding to a changing climate. Spanning nine countries, the Roof of the World retains large areas of wilderness, has a number of Biodiversity Hotspots and Key Biodiversity Areas, and has established large areas of protected areas. However, this region is also one of the areas with the fastest climate change, posing a serious threat to biodiversity. Therefore, there is an urgent need to evaluate climate connectivity on the Roof of the World to support long-term biodiversity conservation in this region. In this study, we collected human impact data, and bioclimatic variables data in the present and multiple future periods of the Roof of the World. Then, we conducted a high-resolution climate connectivity analysis of the Roof of the World based on the least-cost path model. Our results indicated that the existing protected areas were unable to effectively cover areas with high climate connectivity contributions, and many areas across country boundaries were likely to be important for the routes of climate-induced species range shifts in the future. These results recommended developing transboundary connectivity conservation initiatives to help species adapt to climate change on the Roof of the World.

Analysis of the Differences and Influencing Factors of Zoning Conservation Effectiveness in Cross-border Protected Areas: A Case Study of Wuyishan National Park

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Cross-border protection refers to the process of achieving conservation goals across one or more national or administrative boundaries, reducing the impact of artificially drawn political boundaries on the distribution and migration of animal and plant species. China is currently undergoing a national park system reform and optimizing the boundaries of protected areas. The first batch of established national parks integrates various types of natural reserves across provincial and municipal borders, but most areas are still managed in fragmented zones. Evaluating the protection effectiveness of cross-border protected areas and identifying key policy factors can provide technical support for enhancing cross-border collaborative protection. This study takes Wuyishan National Park as an example, evaluates the conservation effectiveness of ecosystem services in the Jiangxi and Fujian zones of Wuyishan National Park through propensity score matching model and InVEST model from 1980 to 2020, and further quantifies the factors of community management policies, community disturbance factors, and socio-economic factors. Based on geographic detectors, the main influencing factors and mechanisms of protection effectiveness are identified. The results show that: 1) there are significant differences in protection effectiveness between the Jiangxi and Fujian zones of Wuyishan National Park; 2) the main factors affecting protection effectiveness include community co-management organization, personnel and capital investment, land use changes, road network density, etc. This study further proposes optimization strategies for cross-border management from the aspects of community co-management, interdepartmental coordination, and ecological compensation.

Multifunctionality in the Alpine Region: An Ecosystem Service-Based Approach

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Mountain landscapes that are managed to provide several ecosystem services (ES) have the potential to sustain high levels of biodiversity while also meeting multiple human needs. The promotion of multifunctional landscapes has become an important policy target in land management and has gained research traction under the definition of ES-multifunctionality. However, scale dynamics and patterns of ES-multifunctionality remain poorly understood and are rarely integrated into land management and policy recommendations. To address this gap, we used two diversity indices to quantify ES multifunctionality based on eleven ES indicators at different spatial scales in a case-study region in the European Alps. The approach used captures the diversity of ES provided at plot and landscape levels (α-multifunctionality) as well as unique ES contributions of ecosystems to the regional ES diversity (β-multifunctionality). Results show that ES-multifunctionality generally decreases from low to high land use intensities and increases from high to low elevations. While forest-dominated landscapes are hotspots of ES diversity, the more specialized ES supply in landscapes above the tree line and on valley floors enhances regional ES-multifunctionality. This study highlights how understanding ES-multifunctionality and its incorporation into policy and landscape management requires adopting a multi-scale approach. Plot-scale analyses are necessary to identify the environmental characteristics underpinning ES-multifunctionality with a fine level of detail. However, looking at the distribution of ES at landscape and regional scales uncovers the benefits originating from interacting ecosystems, and can support the identification of areas that should be protected, restored, or sustainably managed.

Keywords: α-diversity, β-diversity, ecosystem management, ecosystem services, spatial scales

Landscape Un(sustainability): Contextualizing the Problem in Slovenia and Europe

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The sustainability of a landscape is dependent on the way we manage the land. Due to land use changes, landscapes have undergone rapid changes. Man-made landscape changes increase the vulnerability of Slovenian landscapes, leading to land abandonment in rural and marginal agricultural areas on one hand and to the agricultural intensification on the other. These changes affect the harmonious proportions between cultivated land, settlements and forests and call into question not only the sustainability of today's

landscapes, but more importantly their long-term sustainability.

In most European countries, the landscape is the subject of strategic documents and consequently included in various (inter) sectoral programs, agreements, research, projects and guidelines. However, there are still significant gaps in knowledge and policies to manage landscapes in Europe sustainably. This research work tries to contextualize the topic of (un)sustainable landscape management in Slovenia and Europe through theories and case studies from the landscape context.

Housing Growth in the Surroundings of Polish National Parks Threatens their Conservation Values

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Housing growth in the surroundings of Polish national parks threatens their conservation values
Nowadays, urban growth is a major threat to nature conservation at the global scale. One of the defining indicators of the effectiveness of protected areas is their ability to stop habitat loss not only within their boundaries but also in their vicinity. In Poland, there is a particular concern on low-density residential development in rural and open landscapes, which often occurs near protected areas. This may have a significant impact on biodiversity and may cause landscape fragmentation and isolation of protected areas. We collected detailed spatial data on buildings for all 23 national parks (NPs) in Poland and their surroundings, to reconstruct building growth within and around NPs from 1970/80s to 2021, and to estimate the effects of buffer zone creation on changes in landscape patterns. We tried to explain where the largest increase of housing occurred and which variables influenced it. Data on the building were obtained from historical topographic maps and the Topographic Object Database. Our results showed that the density of housing has increased in the surroundings of all NPs, while the rate of growth varies for individual NPs. We found that in several cases the establishment of a buffer zone has been slightly effective in reducing housing growth outside the NPs, and the building growth was slightly lower inside the buffer zone than outside it. However, at the same time, for the other parks, the highest rate of growth was observed, in zones up to 2 km from the NP boundaries. Furthermore, we compared the building data with the population data, and for many areas, the number of buildings increased significantly while the population increased slightly or was of a similar size. Our findings highlight the critical need for effective management and spatial planning at broader scales, incorporating areas beyond the boundaries of NPs.

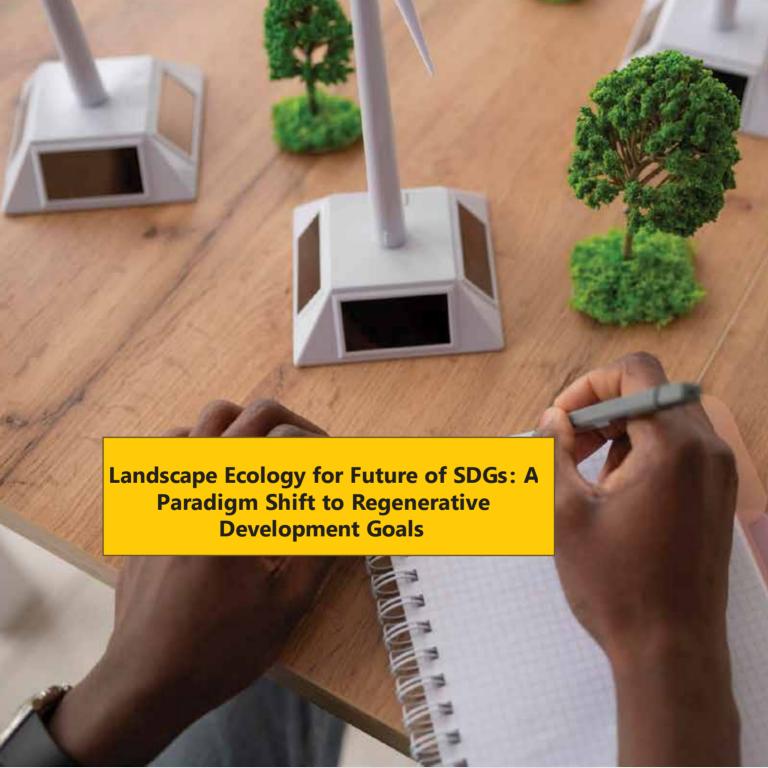## Co-Producing Theory of Change to Operationalize Integrated Landscape Approaches

James Reed[1,2], Colas Chervier[1,3], Joli Rumi Borah[4], Davison Gumbo[5], Kaala B. Moombe[5], Teddy M.

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Integrated landscape approaches that engage diverse stakeholder groups in landscape governance are increasingly promoted to address linked social-ecological challenges in tropical landscapes. Recent research suggests that a transdisciplinary approach to landscape management can help identify common research needs, enhance knowledge co-production, guide evidence-based policy development and harmonize cross-sectorial integration. Meanwhile, guiding principles for landscape approaches suggest that identifying common concerns and negotiating a process of change are fundamental to implementation and evaluation efforts. As such, the use of decision support tools such as theory of change models that build ordered sequences of actions towards a desired, and agreed, future state are increasingly advocated. However, the application of the theory of change concept to integrated landscape approaches is limited thus far, particularly within the scientific literature. Here we address this gap by applying the principles of landscape approaches and knowledge co-production to co-produce a theory of change to address current unsustainable landscape management and associated conflicts in the Kalomo Hills Local Forest Reserve No. P.13 (KFR13) of Zambia. The participatory process engaged a diverse range of stakeholders including village head people, local and international researchers, district councilors, and civil society representatives amongst others. Several pathways, actions, and interventions were developed around the themes of deforestation, biodiversity and wildlife conservation, socio-economic development, access rights and law enforcement. To make the theory of change actionable, participants identified a need for enhanced cross-sector and multi-level communication, capacity development, and improved governance; while a lack of commitment towards coordinated knowledge exchange and access to information along with poor policy formulation and weak enforcement of rules were among potential impediments to action. Use of theory of change can both inform evidence-based policy design (by revealing place-based challenges and proposing solutions) and support policy mechanisms that promote integration between state and non-state actors (by clarifying actor rights, roles, and responsibilities). Co-developing a theory of change for integrated landscape management is inherently context-specific, but the process and outcomes of this study should hold relevance across a range of contexts faced with sustainability challenges related to reconciling both conservation and development objectives.

Landscape Ecology for Future of SDGs: A Paradigm Shift to Regenerative Development Goals

Moving From Sustainable to Regenerative Landscape Designs: Key Challenges and Approaches

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We put forward a framework called Regenerative Landscape Design as a process for finding pattern-based solutions, emphasizing cooperative, iterative, and facilitated engagement for the co-production of locally relevant knowledge for desirable landscape stewardship. We argue that components of regenerative systems, design, and landscape have individually been deployed across disciplines, but have heretofore not been united. We summarize each of these components separately (regenerative, landscape, design) and put forward strategies for a research roadmap to help inspire new frontiers in landscape sustainability methodology and action. First, we review the concept of regenerative systems, which builds upon frameworks such as a complex adaptive systems and resilience. We show that the concept of regenerative systems has been used across fields such as agriculture, architecture, tourism, and urban studies, but has not yet been applied to socio-ecological systems on landscapes. Second, we argue that there is greater potential for landscape ecology principles to identify reciprocal pattern-process interactions that support regenerative systems. Third, we highlight that design approaches can be used both as part of a co-design process to identify solutions in partnership with stakeholders, as well as the physical design of landscape elements, both of which are critical for realizing the full potential of regenerative landscape approaches. Building on these concepts, we present an overview of a new research project in Kenya that explores the deep historical legacies of land tenure together with contemporary perceptions and future projections of climate change to better understand changing agropastoral livelihoods. We use mixed methods approaches (aerial photos of past land use, geospatial analyses of climate data, household interviews, and land use modeling) to explore the past, current, and future potential of landscape change to support regenerative agropastoral livelihoods in the future. We conclude that regenerative landscape design approaches have significant potential to support landscapes and communities that are not only resilient but thriving.

Spatial-Temporal Characterization of Rainfall Variability in Kenya Highlights Vulnerability for Agro- Pastoral Livelihoods.

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Agro-pastoral communities in vulnerable Arid and Semi-Arid Landscapes (ASALs) are contending with multiple environmental challenges that threaten the sustainability of their natural resource-based livelihoods. In recent decades, climate change and variability of rainfall, have exacerbated this vulnerability and worsened aridity in many ASALs. In East Africa, numerous climate controls acting at multiple scales produce spatially heterogeneous rainfall characteristics, but the spatial and temporal scales of variability are not adequately understood. In addition, local experiences and perceptions of climate change held by impacted communities are not commonly integrated with understanding of multiscalar climate drivers. This lack of integration, specifically of contemporaneous observations and experiences of changing climate conditions, hinders place-based adaptation strategies. In this study, we apply the self-organizing maps (SOM) and wavelet analysis approaches to explore spatial patterns of rainfall anomalies and quantify the time domains of rainfall variability. We also explore how the variability is influenced by El Niño–Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) mode. We also surveyed over 100 crop farmers and pastoralists in Narok county, Kenya, to understand the experiences and perceptions of change. SOM analysis results showed positive and negative anomalies that are strongest in high elevation areas and that are becoming more frequent. Wavelet analysis showed presence of seasonal and intra-seasonal variability and interannual variability at the local level, all of which increase after 2012, concomitant with sea surface temperature changes associated with ENSO and IOD. Results from the household surveys indicated that farmers and pastoralists experienced different climate change impacts, reflecting differential vulnerability to climate related hazards. Though local perceptions of change do not coincide precisely with temporal and spatial patterns in the climate data, the differential vulnerabilities of communities to these changes are important to consider when planning adaptation strategies since community actions are highly driven by historical practices.

Cultural Knowledge and Forest Conservation in Headwater Regions: Locational Significance of Sacred Groves in India

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Indigenous groups around the world have revered certain landscape features, ranging from a single tree to an entire mountain range or a river, as sacred. The prevalent belief systems and cultural taboos that give these land parcels spiritual importance in particular and care for the environment in general, result in the preservation of these landscapes, commonly referred to

as Sacred Natural Sites. Sacred groves are numinous forests that are conserved by communities, and are found all over the world. This research examines the spatial distribution of sacred groves in India at a landscape scale, relying upon the case study method owing to the paucity of research in the domain. The geographical location of the sacred groves is examined with respect to drainage-recharge patterns of the landscape. The locations of 9 large sacred groves are identified from secondary sources. The geographical extent of the grove is delineated on Google Earth imagery. The topographical setting and the stream network are generated from SRTM DEM using ArcMap 10.2. It is found that the sacred groves are located at headwater regions of the major rivers in the country. The emerging pattern highlights the biological rationale behind preserving the headwater vegetation, which contributes to preserving the ecological health of the entire watershed. The locational significance of sacred groves brings to light the need to identify and create policies for the preservation of these priceless natural heritage systems that integrate hydrological, ecological, and cultural conservation. The indigenous ecological knowledge contributing to the shadow conservation of headwater regions can inform the efforts towards attaining Sustainable Development Goals. The use of culture and heritage as part of attaining resilient settlements makes climate action more inclusive and brings local knowledge to the forefront.

Keywords: Sacred groves, natural heritage, culture-based solutions, headwater conservation, geographical information systems.

Research on Climate Change Impacts and Response of World Natural Heritage: Taking Mount Huangshan as An Example

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The problem. World natural heritage sites have been seriously affected by climate change. China is among the countries with large number of world natural heritage sites, which have also been affected by climate change. Therefore, it is urgent for China to understand the impact of climate change on world natural heritage sites and to respond accordingly. Methods employed. This paper proposes a natural heritage climate change response framework of "current status assessment - future risk assessment - response targets - response measures". And it takes Mount Huangshan, a famous world heritage site of China as an example to practice the framework. Firstly, the impacts of climate change on Huangshan and the current responding measures were sorted out respectively. Secondly, based on the data of future climate scenarios, the vulnerability assessment results of biodiversity value and beauty value of Huangshan in 2021-2040 and 2081-2100 were obtained, by using the Vulnerability-Scoping-Diagram (VSD) risk assessment model. Thirdly, the MaxEnt model is used to assess the change of suitable habitat for the representative species of Muntiacus crinifrons, so as to supplement the former climate change risk assessment results. Finally, according to the results of current problems and risk assessment, some response suggestions is put forward.Major results and

conclusions. In the future, during 2081-2100, the vulnerability of most regions of Mount Huangshan will further increase, and the regions with higher vulnerability will expand outward. According to the simulation results of the Muntiacus crinifrons suitable habitat, the habitat of Muntiacus crinifrons will be rapidly reduced to the high-altitude area in both Anhui province and Huangshan region in the future. And Huangshan, as an important suitable habitat, will gradually weaken the connection with the surrounding suitable habitats. Based on the above analysis and international experience, it is suggested that future response should be carried out in five aspects: improving OUV adaptation ability, improving managers' climate response ability, improving community cooperation mechanism, improving Huangshan's climate mitigation ability, and enhancing planning and policy support.

Do Diet and Health Metrics of Rural Households Differ Based on Forest Fragmentation?

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Forests directly support nutrition and food security by providing wild foods for consumption; however, little is known about the role that forest age and fragmentation may play in this complex process. One's ability to obtain nutritious and diverse foods may vary with forest age, size, edge length, etc. Understanding the spatial trends of the association between forests and local diet provides valuable information for landscape-level management of nutrition. This research takes place across the montane forests of Kenya's Rift Valley. I aim to investigate the following research question: Do diet and health metrics of rural households differ based on forest age and fragmentation?

To investigate this question, we analyze Landsat-derived landcover classifications in combination with household survey data collected by the Demographic and Health Surveys (DHS) program. Firstly, data obtained through DHS was analyzed to identify the location, dietary trends (dietary diversity; number of days within the past 7 days that fruit/vegetables/meat/dairy/eggs/grains/pulses/nuts and seeds were consumed), and child/mother health metrics (height-for-age/weight-for-age/weight-for-height/body mass index standard deviations based on WHO reference standards) of 1415 rural households within our region of study. 24 years of landcover data (obtained from the Kenya Department of Resource Surveys and Remote Sensing) were then analyzed to calculate forest patch age, cover, and fragmentation within a 10km radius of households. We expect to find a positive relationship between fragmentation and diet, as well as between fragmentation and mother/child health. While fragmentation could reduce the production of foods (especially of late-successional species), a fragmented landscape may allow for human-dominated areas to be more integrated amongst forest patches, thus increasing food accessibility. Currently, forest restoration plans within the study region are underway. This research will provide decision-makers with a better understanding of the potential trade-offs associated with forest restoration and human nutrition. In addition to collaboration with local communities, the

findings of this research can be used to identify realistic scenarios in which restoration would be beneficial. Furthermore, these findings may inform the value of smaller forest patches and isolated trees growing outside of forests in supporting the food security of forest-dependent communities. It is generally believed that an intact forest promotes optimal ecosystem service provision; however, my findings may present fragmented forest patches as a more accessible ecosystem service source.

Assessing the Vulnerability of Small-Scale Water Resources Using High Spatial Resolution Remote Sensing

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Water stress due to physical scarcity and poor water quality impacts billions of people worldwide. Internationally, an important goal of the United Nations' Sustainable Development Goals is to track the proportion of inland water bodies with acceptable water quality. Thus, there is a global, pressing need for fast, reliable, and accessible ways to monitor the water quality in small inland water bodies. In this study, we evaluate the utility of high spatial resolution remote sensing for monitoring water quality constituents (Chlorophyll-a and turbidity) in small reservoirs (0.01 km2) in Narok, Kenya. We used a novel combination of remote sensing indices and landscape features to build statistically robust empirical models of water quality parameters that were verified in situ. These models were then used to extrapolate water quality in 60 reservoirs over 43 consecutive months (2019-July 2022) across a land-use gradient. Finally, high spatial resolution imagery was used to quantify the areal change (or drying out) of reservoirs throughout a single dry season. Overall, Sentinel-2 imagery produced stronger models of Chl-a (R^2 = 0.66) whereas PlanetScope imagery produced stronger models of turbidity (R^2 = 0.72). From 2019 to 2022, Chl-a and turbidity have been steadily improving in 40% and 32% of reservoirs, respectively. Additionally, nearly half of reservoirs lost over 50% of their surface area during the 2021 dry season, whereas a quarter of all reservoirs dried out completely. This research has the potential to help support monitoring and planning for climate resilient infrastructure such as small-scale reservoirs.

Developing Resilient Upland Areas Through Sustainable Landscape Planning

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Upland areas play a very important role as they include watersheds that cater to the conservation of water resources and the maintenance of stable land ecosystems. This paper presents the gains and opportunities for creating successful upland environments in General Santos City through the implementation of an upland and watershed conservation management plan. The city, located in the

southern Philippines, has been uniquely endowed with upland areas constituting about 70% of its total land area and is divided into protection and production forests that are crucial for ensuring food and livelihood security. Most of the population in these upland areas are indigenous people while a large number are also tenured migrants. Unfortunately, they are engaged in unsustainable forest farming practices such as slash-and-burn and forest poaching, along with other factors that contribute to watershed degradation. Such a destructive system is even exacerbated by the effects of drought and other several climate-related environmental hazards that pose concerns for the landscape's management and sustainability. Having a management plan that is aligned with the local government's mission of increasing community and ecosystem resilience to human-environmental threats, the city can deliver practical, cost-effective approaches that ensure healthy landscape ecosystems, which enable the communities to generate and maintain valuable goods and services and prevent the need for costly technological solutions to environmental and social problems. Through empowering communities to be responsible environmental stewards and by strengthening the mechanism for landscape governance through the institution of sustainability and resilience components, this localized approach to sustainable landscape planning is expected to develop upland areas that will benefit both current and future generations.

Keywords: resilience, upland, governance, planning, human-environment

The Deep Global History of Transformative Landscape Change

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For millennia across the planet, human societies have reshaped landscapes into the multifunctional mosaics that now sustain both people and the rest of terrestrial nature. Recent assessments of this deep global history of human transformation of landscapes reveals their legacy in shaping biodiversity and ecosystems across the planet today. Through advances in evolutionary theory, evidence from archaeology and history, and investigation of emerging trends in human societies and their reshaping of the terrestrial biosphere, the prospects emerge for guiding social-ecological processes towards a better future for people and the rest of life in the Anthropocene biosphere.

Landscape Solutions to Human-Wildlife Conflict Management: Government to Grassroots

Challenges Of Integrating the Ecology and Human Dimensions of Wildlife at the Landscape Level

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Wildlife management involves ecological and social processes that transcend land ownership and sociopolitical boundaries, often prompting coordinated action among many stakeholders. At the landscape level, this process is complicated by the diverse number of organizations and entities, management objectives, and land ownerships involved in decision-making. During the past two decades, an exciting frontier has been developing involving the integration of ecological and social data into the landscape-level study and management of wildlife. However, there often is a lack of coherence and integration of these data into landscape analysis for several reasons. Our objective was to synthesize the current state of the discipline of integrating ecological and social wildlife-based data, and to explore how major findings and limitations may contribute to future directions of wildlife management. We completed a global synthesis of the English literature from 2000 to 2022 that focused on socio-ecological integration and modeling of wildlife issues across landscapes. This synthesis was used as a basis to highlight examples from recent and current research projects that include wildlife species from small to large, and a diversity of countries and stakeholders. Findings enunciated importance of considering the spatial context in shaping human attitudes toward wildlife and human-wildlife interactions, and highlighted the need to overcome a tendency to oversimplify both ecological and human dimensions data in understanding feedbacks between human and wildlife processes. Challenges and limitations included spatial scale mismatches between those used by ecologists and social scientists used to collect data, lack of balance in integration of the disciplines, missing important historical contextual pathways, and inconsistency in application of theoretical frameworks and developmental accuracy of variables applied. We suggested pathways forward for enhancement and integration of frameworks from both ecological and social disciplinary directions to better understand the complexity of human-wildlife interactions.

Keywords: attitudes, human dimensions, socio-ecological systems, spatial analysis, wildlife management

A Need for Land-Sharing Governance Strategies to Promote Human-Carnivore Coexistence: Case Studies from India and Germany

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History of extirpation of large carnivores led to a land-sparing model for conservation. After around half a

century, this model helped revive several species from the brink of extinction. At present, global patterns suggest an increasing trend in large carnivores using shared landscapes that leads to human-carnivore negative interactions. Hence, reforms in current governance approach of carnivore conservation has been called for. In our study, we investigate challenges in the current governance models in the shared landscapes of two socially-culturally and economically distinct countries, India and Germany. We focus on the Bengal tiger (Panthera tigris tigris) and the Eurasian wolf (Canis lupus lupus) conservation and conflict management, in respective countries. With a dual methodological approach of review of legislative documents and interview of experts, such as the policy-makers, stakeholder representatives, conservation and social scientists, (n = 36), we highlight governance-related challenges in the shared landscapes. Our qualitative content analysis approach revealed disparities in balancing the conservation goals and addressing conflict issues. In both countries, the social elements are maintained through public relations and providing compensation payments for livestock losses. However, gaps in its implementation affect the social carrying capacity in the landscapes. We recommend that the countries need to invest in setting-up institutional structures that engages actively outside the protected areas, both financially and technically. We also provide country-specific landscape-level recommendations to foster the new institutional arrangements that could help promote coexistence scenarios in the two countries.

Exploring the Relationships Between Local Participation and Perceived Co-management Performances: Evidence from China's National Park

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Understanding local perceptions is essential to secure the proper functioning of co-management in protected areas. However, scientific investigations have virtually ignored the quantitative assessment of the extent to which shall locals be empowered to ensure optimistic judgements towards co-management. Against this background, this paper seeks to investigate the effects of varied participation types and levels on perceived performances in a centralized co-management regime in Giant Panda National Park, China. Using 17 semi-structured interviews and 353 survey questionnaires, our research identified six co-management subtypes, classifying into four empowering levels: instructive, consultative, agreement and cooperative degrees. Surprisingly, the multivariable analysis points to a very sobering fact that the involvement in the equally cooperative level (type) is not significantly linked with more favorable perceptions. In contrast, local residents engaged in the lowest instructive level of co-management (supportive, training, and employment subtypes) are inclined to develop positive attitudes across ecological, social and livelihood dimensions. This study has come up with a succinct conclusion that merely empowering locals might not facilitate perceived successes among local dwellers, and the enforcement of instructive co-management intending to enhance local

well-being is commendable, particularly in a top-down co-management regime. In addition, this paper advocate for more attention to increasing the livelihood impact of co-management policies, especially for the low-income, elder, and less educated groups residing around China's national parks.

Major Threats to Biodiversity Conservation in The Proposed Transboundary Biosphere Reserve (Tbr) Between Nigeria and Cameroon

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The creation of Transboundary Biosphere Reserves (TBR) is crucial to the sustainable management of the Oban and Okwangwo Biosphere Reserves in Nigeria and the Korup and Takamanda National Parks in Cameroon. Nigeria and Cameroon are working towards designation as a UNESCO Transboundary World Heritage Site and/or UNESCO Transboundary Biosphere Reserve. The transboundary region formed part of one of the lowland rainforests refugia during the last glacial period and as a result is now a centre of endemism and diversity, particularly for reptiles, fish, amphibians, and birds, endangered taxa such as the Cross River gorilla (Gorilla gorilla diehli), Nigeria-Cameroon chimpanzee (Pan troglodytes ellioti), drill (Mandrillus leucophaeus), and the Critically endangered slender-snouted crocodile (Mecistops cataphracts). In Nigeria side, logging has been the major threat to biodiversity conservation in the region, other threats are poaching, intensive and extensive agriculture, illegal entry, collection of Non-Wood Forest Products (NWFP), inadequate funding, and bush burning. Poaching, agricultural encroachment (from industrial plantations and villages located within the park), and logging continue to pose serious threats in Cameroon. All the identified threats are caused by poverty, weakness, and the laxity of forest governance. There is ample proof that the dangers are detrimental and frequently connected effects on the environment, economy, and society. A consequence of indiscriminate logging hinders the significant role that rainforests play at the global level in climate change mitigation, oxygen production and carbon cycling. Stakeholders involved in the conservation of the region must intensify conservation education, strengthen security facilities and actively involve community members in decision-making.
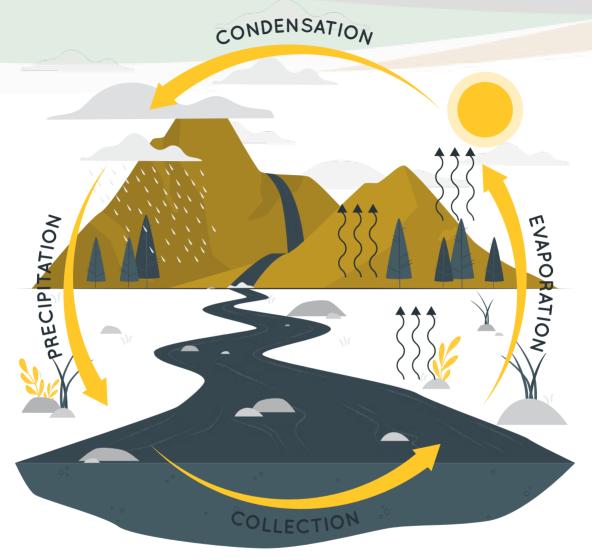
Keywords: Protected Areas (PA), Community, Co-management, Local Empowerment, Effectiveness, Perceptions

Explore The Sustainable Development Path of Communities of the Giant Panda National Park, China

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The problem. There is a large population in the inner and surrounding areas of Chinese national parks, and the contradiction between protection and development is prominent. The community sustainable development problem has not found an effective solution. It is of great significance to explore the sustainable development path of national park community, promoting the harmonious coexistence between man and nature. Methods employed. The research takes the Giant Panda national park, one of the first Chinese national parks, as the case, to study the sustainable development path of national park community. The research mainly includes three aspects. (1) To summarize former experience in the sustainable development of communities within and around national parks; (2) To analyze the opportunities and challenges for sustainable community development after the construction of national parks; (3) To put forward the key system and policy suggestion for the sustainable development of Chinese national park communities. Major results and conclusions. The innovation of the project. (1) To define the connotation and characteristics of "sustainable development of China's national park community" in an innovative way. (2) Through multi-level social investigation, innovatively construct the driving mechanism of policies for the sustainable development of national park communities from an empirical perspective. (3) Innovatively summarize the sustainable development model and path of China's national park community.

Mountain Landscape Ecological Pattern and Function: Response to Climate Change and Adaptive Management

Using MicaSense Altum and CASI Airborne multispectral Imagery for the Detection of Subalpine Grassland Mortality Events in the Hrubý Jeseník MountainRrange in the Czech Republic

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Rapid climate changes strongly affect alpine ecosystems mainly due to altitudinal zonality. The southern part of the Hrubý Jeseník (Eastern Sudetes, Czech Republic) is not an exception: several large events of sudden grassland mortality have been observed there during the past two decades. Core subalpine grassland types (Nadrion strictae, Juncion trifidi), occupying heights of 1300 – 1491 m a.s.l., continue to be at different stages of recovery. We studied the potential of high-resolution airborne multispectral imagery for the quick and reliable detection and precise mapping of subalpine grassland health status: captured with drone-based MicaSense Altum 6-band camera (spatial resolution 0.075 m) and aircraft-based CASI hyperspectral sensor (spatial resolution 0.5 m), both taken in July 2022 at the peak of vegetation season. 450 reference points of damaged and healthy grassland were collected in the field at the same period of time. For detection, we calculated and compared statistics on spectral indices, recommended in the literature for non-photosynthetic biomass estimation. Those containing Red Edge band (LCI, NDRE) have demonstrated the best results not only for dead biomass detection itself, but also for dead/living ratio estimation in coverage (LCI: $R2 = 0.874$, RMSE=0.037; NDRE: $R2 = 0.851$, RMSE=0.048). CASI-based LCI with threshold values 0.33–0.42 showed the best performance in distinguishing dead grasslands from degraded and wind-swept living grasslands (0.42–0.50) and bare land (<0.33). Moreover, 869-883 and 1012-1026 nm wavelengths of CASI appeared to be the most reliable to differentiate dead grass from dead wooden debris. On the whole, 17.3 ha (7.17%) remains covered by 50-100% dead biomass out of 241.4 ha of grasslands in total.

The Evaluation and Mapping of Ecosystem Services in A Mountain Protected Area: The Case of the Climate Regulation Service at Adamello Regional Park (Italy)

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Despite the relevant role played by alpine protected areas in providing many ecosystem services (ES), there is still a lack of an appropriate evaluation of them, by directly quantifying through fieldwork. Given the importance and the vulnerability of these environments, there is an urgent need for assessing the current supply of ES. In this study we evaluated the provision of the climate regulation in an alpine protected area located in Italy, the Adamello Regional Park, using the Organic Carbon (OC) stock as indicator. We investigated a total of 118 plots. Data on mineral soil were collected by depth layers (0-10cm, 10-20cm, 20-40cm), litter was collected by horizons, whereas trees species were

described and measured using DBH (Diameter at Breast Height) and Height. We evaluated and mapped the OC stock across the most representative habitats, namely grasslands, spruce forest, larch forest, chestnut forest, mixed coniferous forest, mixed deciduous forest and Alnus viridis shrubland. Further data on study area, soil description (WRB classification) and tree vegetation structure and biodiversity were collected. The results showed that mixed coniferous forests constituted the habitat associated to the highest values for OC stock both in mineral soil (24,1 kg/m2) and tree vegetation (9,6 km/m2), whereas mixed deciduous forests had the lowest values for both mineral soil (8,5 km/m2) and vegetation (5,2 kg/m2). Statistical analyses were undertaken to detect correlations between the features and resulted in a significant correlation of higher elevations and LAI with the OC stock in soil, whereas pH correlated negatively with OC stock in vegetation. Further investigations will be carried out to determine the cause-effect of the correlations found and to develop a model for the estimation of OC stock in alpine areas.

Retrospective Analysis of The Sudden Mortality and Recovery of Subalpine Grasslands in the Czech Republic Using Remote Sensed Satellite Data

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Satellite multispectral imagery archive is an invaluable source of reliable information on ecosystem change. Remote sensing techniques were used to detect the beginning of sudden subalpine grassland mortality events as well as to establish their extent at Hrubý Jeseník mountain range (1300 – 1491 m a.s.l.) in the Czech Republic. As the baseline, the current extent of dead grasslands was detected using random forest supervised classification of composite image, consisting of selected CASI sensor band values combined with a number of spectral indices (LCI, NDT7, DFI) sensitive to non-photosynthetic biomass (NPB) content. The algorithm was trained on >600 field reference polygons. To perform the transfer from airborne to satellite sensors, OLS linear regression was applied, comparing NPB indices pairwise: CASI/Sentinel-2 (August 2022), and Sentinel-2/Landsat 5&7 (August 2015). Thus, the thresholds for the most reliable indices for satellite-based NPB detection were found: Sentinel-2 LCI 0.300 – 0.400 and Landsat 5&7 NDT7 0.110 – 0.179. These results have become a practical tool for the historical analysis of subalpine grassland mortality events. All summer Landsat 5 TM and Landsat 7 ETM+ (1984 – 2015) and Sentinel 2 (2015 – 2022) images available for defined study area were analyzed and three large grassland mortality events were detected: in 2003 (0.24 ha), 2012 (3.44), and 2019 (8.25 ha of mortality damage). Archival weather data suggest that each mortality event was probably the consequence of exceptional spring/early summer droughts and/or heat waves, observed simultaneously. However, specific locations and the limited extent of dead grassland spots highlight the role of local microclimatic and orographic factors. These findings will be used for the predictive modelling of the risk of subalpine grassland mortality events.

Assessing the Suitability of Protected Area Networks to Protect Alpine Biodiversity in A Changing Climate

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The biodiversity of alpine rivers worldwide is in danger due to the rapid warming that is causing glacier retreat. However, predicting the future distributions of specialized cold-water species is a challenging task. In this study, we aim to address this issue by combining glacier projections, hydrological routing techniques, and species distribution modelling to assess the impact of glaciers on 15 alpine river invertebrate species in the European Alps from 2020 to 2100. Our findings show that glacial influence on rivers will gradually decrease over time, and river networks will expand into higher elevations at a rate of 1% per decade. The modelled species are expected to shift their distribution upstream in areas where glaciers remain but become functionally extinct in areas where glaciers disappear completely. Some alpine catchments are projected to provide climate refuges for cold-water specialists. However, current protected area networks provide inadequate coverage of these future refuges, indicating the need for changes in alpine conservation strategies to address the future impacts of global warming.

Increasing Impact of Climate Change and Human Activities on Runoff Variations in the Last 60 Years in the Yellow River Basin, China

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Quantitative analysis of the impact of climate change and human activities on runoff is of great significance for water resources management. In this study, based on the meteorological and runoff data, the Mann-Kendall trend test, moving t-Test techniques, and the Budyko elastic coefficient to reveal the effect of climate change and human activities on runoffs in the Yellow River Basin (YRB) in China. The results show that the temperature increased significantly in the YRB from 1960 to 2020. The precipitation increased insignificantly in the YRB and the upper YRB (UYRB), while it decreased insignificantly in the middle YRB (MYRB) and lower YRB

(LYRB). The potential evapotranspiration decreased insignificantly in the YRB, UYRB, and LYRB while increasing insignificantly in the MYRB. The runoffs reduced significantly in the UYRB, MYRB, and LYRB from 1960 to 2020, positively related to precipitation and negatively related to potential evapotranspiration and land surface elements. The runoff change in the LYRB was most sensitive to the changes of various factors, followed by the MYRB and the UYRB. Climate change in the MYRB and UYRB significantly influenced runoff change from 1969 to 1985. Human activities considerably affected runoff change during 1986-2020. The impact of human activities on the shift in runoff in the UYRB, MYRB, and LYRB has enhanced. The runoff in the UYRB, MYRB, and LYRB had decreased due to climate change and human activities. There was an enhancing effect on the runoffs of human activities, which may lead to a severe conflict in water use and significantly impact the watershed ecological conditions. The adverse effects of climate change and human activities on runoff variations can be reduced by rational planning and optimizing land use. More attention should be paid to efficiently utilizing the limited water resources and the governance of human activities.

Surface Warming Trend of The Gongga Mountain in the Southeastern Tibetan Plateau and Its Driving Forces

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As the highest mountain in the southeastern Tibetan Plateau, Gongga Mountain is highly sensitive to climate change which is hardly assessed with limited meteorological stations in this region. To analyze the warming trend of Gongga Mountain, the mean annual surface temperature (MAT) was extracted based on an annual temperature cycle model with the MODIS/Terra daily land surface temperature (LST) product and used to identify the MAT trends from 2000 to 2018 using the Mann-Kendall trend test. The results indicate that almost all the pixels passing a significance test with the confidence level of 95% show an increasing trend, and the daytime MAT exhibited a stronger warming trend with the mean rate of 0.11 K/yr than the nighttime MAT (0.07 K/yr). However, more pixels (30.2%) exhibited significant warming trends at night than during the daytime (21.6%). Additionally, the significant warming pixels were mainly distributed above 3,200 m, and the number of pixels increased with elevation. Most importantly, the statistics of the daytime and nighttime changing rates at different elevation ranges support elevation-dependent warming (EDW). These warming patterns are connected to changes in snow and cloud cover and the rate shows good correlations with the changes in clear-sky days and vegetation cover conditions. In general, this study verifies that remotely sensed LST can be used to analyze the warming trends in mountain areas and identifies the presence of EDW at Gongga Mountain. This trend could result in a strong influence on the local mountain ecosystem functions, water resources, and glacial changes.

Mountain Tree Radial Growth Response to Climate Change

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Mountain forests are of particular importance in maintaining biodiversity, protecting from natural hazards, and in regulating the water and carbon cycle. Ongoing climate warming in mountain areas is amplified with elevation, and its impact on forest landscape is still a major question in global change biology. Tree-ring widths are a sensitive index for forest response to climate change. Generally, tree radial growth is expected to increase at higher elevations under climate warming, while lower elevation tree growth is expected to decline. However, numerous studies have found tree radial growth responds consistently to climate along elevational gradients. To address this question, I conducted a case study on the Gongga Mountain in the eastern Tibetan Plateau to determine tree radial growth trends and responses to climate. Three commonly used detrending methods all consistently showed that tree radial growth at high elevation (> 3100 m) increased, while tree growth declined at the lower elevations (2700 m and 2900 m) over the last three decades. Increasing late-growing season temperature positively ($p < 0.05$) correlated to tree radial growth at higher elevations, but the sign of this relationship reversed to become negative at lower elevations. Moving-window correlation analyses indicated the difference between high and low elevations response to temperature variation increased strongly with warming. Placing the result into the global context, 62% of 39 published studies found that trees along elevation gradients respond divergently to warming, and that these are located in warmer and wetter regions of the Earth. Notably, 28% of studies found non-significant responses to temperature at both high and low elevations. The findings in the subalpine mountain forest in the eastern Tibetan Plateau were consistent with the majority of published datasets, and imply increasing temperature benefit for tree populations at higher elevation, while warming dampens growth at lower elevations.

The Effect of Nitrogen Deposition on N2O Flux Mainly Depends on Microbes Rather Than Substrates Supply

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Abstracts: Forest soil is an important source of nitrous oxide (N2O) emission that is suggested affect by nitrogen (N) deposition significantly. However, the mechanisms of N2O flux in response to N addition is

unclear as well as its response in different time scale. Here, in a N-limited forest ecosystem, we explore the effect of N addition on N2O fluxes and the mechanism in three N addition levels experiment for two-year in-situ observation at an hourly scale. High frequently sampling revealed that the N2O pulse increase appears after 4 hours with N addition, which was attributes to increased concentration of substrates supply. N addition significant increased annual N2O fluxes while the effect of low N addition was stronger than high N addition, this results mainly depended on the abundance of microbial functional genes that could explain the variation of N2O flux of 77%. These results suggested that important role of microorganisms in N2O emission under N deposition even in N-limited ecosystem, which should pay more attention in the future study.

Key words: Nitrogen deposition; N2O pulse; High frequency subsampling; Microbial functional genes

Protecting Biodiversity under Climate Change in China's National Parks: A Climate Analogues Approach to Conservation Network Design

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Conserving biodiversity in the face of climate change requires landscape strategies at larger regional scales, and expanding the network of protected areas is one such strategy. In China, a protected area system is being established, with national parks as the main body, providing a promising avenue for building a conservation network around them. However, there is still a pressing need to explore the extent to which a national park's landscape strategy should extend beyond its boundaries and determine which protected areas it should connect to. This study proposes a novel method for defining the extent of a conservation network using climate analogs and we apply it to the first five national parks in China, mostly located or partially located in mountainous areas. Specifically, we (1) evaluate the climate analogs of the five parks under four scenarios and three time periods within a 500km buffer, (2) map two type of zones as the conservation network extent, (3) list the protected areas that should be included in each park's conservation network, and (4) calculate climate corridors for each conservation network. The study findings demonstrate significant differences in climate analogs among the different national parks, with the Northeast Tiger and Leopard National Park facing higher climate risks than other national parks. Most national parks experience shrinking climate analogs as time and climate change progress. The proposed conservation network construction plan based on climate analogs provides a reference for constructing a protection network centered on important protected areas under climate change. Most national parks will need to establish a conservation network across provinces, even across countries, to connect the national park with its future climate analogues. The proposed conservation network construction plan based on climate analogs provides a reference for constructing a protection network centered on important protected areas under climate change.

The Response of Mammal Populations to Abrupt Changes in Fire Regimes in Montane Landscapes of South-Eastern Australia

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Fire regimes, climate and topographic gradients interact to influence ecosystem structure and function across fire-prone, montane landscapes worldwide. Biota have developed a range of adaptations to historic fire regime thresholds which allow them to persist in these environments. In south-eastern Australia, a signal of fire regime changes is emerging across these landscapes, and anthropogenic climate change is likely to be one of the main drivers of an increase in burnt area and more frequent wildfire over the last 25 years. This shift has the potential to modify vegetation structure and composition at broad scales, which may lead to landscape patterns to which biota are not adapted, increasing the likelihood of local extirpation of some mammal species. This research addresses these concerns by asking: How do abrupt changes in fire regimes influence mammal populations in montane landscapes? We first examined the impact of climate, topography, and vegetation on fire patterns, and then explored the consequences of these changes on mammal populations and their habitats. Field studies were undertaken across diverse vegetation, fire severity and fire frequency gradients, utilising camera trapping and passive acoustic monitoring methodologies and the collection of fine-scale vegetation data. Results show that drought is a primary contributor to fire regime shifts at the landscape scale, while topographic factors have a variable influence on wildfire occurrence at finer scales. Frequent, high severity wildfire influenced forest structure and composition at broad spatial scales, and at fine scales it reduced occurrence of hollow-bearing trees and promoted coarse woody debris. Mammals responded differently to shifts in forest structure and composition depending on their habitat requirements. This study highlights the complex interplay between fire regimes, environmental gradients, and biotic adaptations across temporal and spatial scales. It emphasizes the importance of understanding complex interactions to effectively manage fire-prone ecosystems in the face of climate change.

Toward Human-Nature System Sustainability for Alpine Grassland Resources in the Three Rivers Source Region (TRSR) of Qinghai-Tibetan Plateau, China

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The three rivers source region (TRSR) is in the hinterland of the Qinghai-Tibetan Plateau, with an average altitude of over 4500m. As the source region for the Yangtze, Yellow, and Lancang-Mekong rivers, the TRSR is important to both its own ecological security and that of downstream areas. However, the ecosystem in TRSR is extremely sensitive to global changes, and it is crucial

to find a balance between human utilization and environmental maintenance. We propose a new approach to partition vegetation productivity to achieve a win-win outcomes for both nature and humans. The spatial and temporal patterns of the ANPP that can be used for human activities (UANPP) the main driving factors of the UANPP variation in the TRSR during 1979–2016 were explored. The results revealed that (1) the annual total UANPP in the TRSR was 13.22 TgC, approximately accounting for 47% of total ANPP. (2) The areas with negative UANPP values accounted for 17% of the entire TRSR, and they were primarily located within the Nature Reserve of the Yangtze and Yellow River source regions, while three-quarters of the area exhibited improvement trends. (3) The regional mean UANPP significantly increased during 1979–2016, at a rate of 0.28 gC m−2 year−1 (p < 0.01), meanwhile the 87% of the area exhibited increasing trends. (4) The UANPP in most areas of the TRSR was strongly correlated with precipitation, and the effect of human activities on the UANNP increased slightly during the 38-year study period. The UANPP represents the upper limit of human use of nature. These findings provide a reference for policy-makers to make decisions toward human-nature system sustainability while meeting human needs for grassland resources. ANPP allocation between nature and human system is a potentially important tool from the standpoint of sustainable development.

The Spatio-Temporal Pattern of WUE And Its Response to Climate Change Along Elevation Gradient in Southwest China

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Water use efficiency (WUE) is a key characteristic of ecosystem function, and reflects the trade-off relationship between carbon gain and water loss. The coupled relationship between carbon and water is complex for ecosystems, especially along elevation gradient. A foliage stable carbon isotope method and the AVIM2 model were used to study the temporal and elevational pattern of carbon gain, water loss and WUE in subalpine dark coniferous forests. The results showed that monthly WUE in wet season was larger than in dry season. The diverse response curves between carbon gain, water loss and meteorological factors determined the monthly variation of WUE. Both the carbon gain and water loss decreased as elevation increased. The carbon gain exhibited moderately decreasing rate compared with that of water loss along the elevation gradient. Plant WUE (GPP/Et or NPP/Et) exhibited an increasing trend along the elevation gradient, comparing with ecosystem WUE (GPP/ET or NPP/ET) only increased from 2800 to 3500 m a.s.l. and slightly decreased as elevation continue increasing to 3700 m a.s.l. The asynchronous response of carbon gain and water loss to climatic and physiological variables determined the temporal and elevational patterns of ecosystem WUE. Warmer temperatures have negative effects on gross primary production (GPP) and net primary production (NPP) in growing seasons and positive effects in dormant seasons due to the variation in the leaf area

index. Warmer temperatures tend to generate lower canopy WUE and higher ecosystem WUE in Abies fabri. However, warmer temperature together with rising CO_2 concentrations significantly increase the GPP and NPP in both growing and dormant seasons and enhance WUE in annual and dormant seasons because of the higher leaf area index (LAI) and soil temperature. CO_2 has the potential to partially alleviate the adverse effects of climate warming on carbon gain and WUE in subalpine coniferous forests.

A 20-Year Ecotone Study of Mountain Forest Vulnerability to Changing Snow Conditions

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Global climate change is expected to significantly alter growing conditions along mountain gradients, causing warmer temperatures and decreased snowpack at higher elevations. Landscape ecological patterns are likely to shift significantly as species attempt to adapt to these changes. We evaluated the extent to which spatial (elevation, temperature, and canopy cover) and temporal (decadal trend and El Niño Southern Oscillation / Pacific Decadal Oscillation) factors impact seasonal snowmelt and forest community dynamics in the western hemlock-true fir ecotone region of the Oregon Cascades, USA. To conduct this study, western hemlock (Tsuga heterophylla) and true fir (Abies spp.) seedling data were collected over 20 years (2002-2022) from five sample transects strategically located to cross the ecotone. Additionally, daily temperatures and light intensity for the five transects were collected using more than 60 HOBO data loggers over the same period. These data proved highly reliable for estimating below-canopy snow metrics, which were validated using time lapse cameras. Relative to standard daily MODIS snow products (MOD10A1.5) for the region, the resulting field estimates of snow cover were at the finer resolution necessary to study forest regeneration dynamics. They also captured a later seasonal snow melt than the MODIS-based estimates. Analyses with this new data set revealed snow season variability that was most significantly impacted temporally by cyclical ENSO/PDO climate patterns and spatially by differences in canopy cover within the ecotone. The associated seedling analysis identified clear sorting of species by elevation within the ecotone, but reflected a lack of long-term trend as species dominance in the seedling strata did not significantly shift along the elevation gradient over the 20-year study. The results highlight the importance of below-canopy, fine-resolution measurements and influence of climatic oscillations in understanding the vulnerability of mountain areas to the changing climate.

Temporal and Spatial Response of Land Cover and Landscape Pattern to Climate Change in the Qinghai-Tibet Plateau

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With its special location, complex geomorphology, and rich resources, the Qinghai-Tibet Plateau has important climate regulation, ecological security, and unique geographical significance for China and the world. Evaluating changes in ecological quality of the Qinghai-Tibet Plateau is an important inspiration for regional ecological conservation and global change research. However, climate change has caused ecological disturbances in mountain landscapes, affecting their ecological patterns and functions. Therefore, in this paper, a predictive model of the relationship between climate change and land cover based on artificial neural networks was developed to analyze the relationship between climate change and land cover and landscape pattern in the Tibetan Plateau region from 2000 to 2020, and to assess the scenarios of permafrost degradation due to climate warming, vegetation cover reduction due to precipitation changes, and species adaptation capacity reduction. The results of the study provide important references and support for ecological conservation and sustainable development of the Tibetan Plateau.

Keywords: Climate change; Land cover; Landscape Pattern; Neural network; Tibetan Plateau

A Review on Understanding the Climate Change and Its Impact in The Himalayan Region: A Geospatial Approach

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Remote sensing is an important tool to understand the earth surface processes and its dynamics in space and time. Under the ongoing climate changes, the earth surface features and processes have been significantly modulated. For examples, the glacier cover, snow covers have been significantly declined during last century. Similarly, the frequency of landslides and its occurrence has been impeded in response to climate change. The occurrence of extreme weather events, such as flash floods has also been impacted heavily under the scenario of climate change. Most notably, the GLOF has got a greater impetus during recent decades in response to the cryosphere wastage. The changing climatic regime and the subsequent occurrence of frequent natural disasters have caused huge loss to economic and other infrastructural domains. It is very imperative to understand the earth surface features and processes using the geospatial technology which is readily available with robust tools and datasets that are freely available. In this study an extensive literature survey was conducted to understand the impact of changing climate on snow cover change, glaciers, river flow, and occurrence of natural hazards. This chapter also provides an overview of roles and applications of Geospatial technology (Remote Sensing and GIS) in the management of natural hazard such as Landslides,

GLOFs, Floods etc. Finally, top 10 research questions pertaining to most pressing knowledge gaps and research priorities in climate changes studies and natural hazard management in the Himalayan region will be identified through the peer reviewed scholarly literature. These knowledge/research gaps will encourage the researchers and other national and international funding bodies to address them.

Keywords: Climate change; Glacio-hydrology; Natural hazards management; Geospatial technology; Research Gaps; Himalayas.

Elevational Variations in Stem Hydraulic Efficiency and Safety of Abies Fabri

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The structural and functional traits of coniferous trees can reflect their growth states and adaptive strategies to a harsh environment. However, it is still unclear if and how hydraulic traits of subalpine conifers change with altitude. Therefore, the changes in stem hydraulic characteristics of Abies fabri along an elevational gradient (2700 m to 3700 m asl) were identified in a subalpine ecosystem in southwest China. Xylem hydraulic efficiency decreased with increasing elevation. Surprisingly, higher hydraulic dysfunction and vulnerability to embolism occurred at higher altitudes. The trade-off between hydraulic efficiency and safety was weak in A. fabri at higher elevations. Low temperature and superfluous precipitation may be the main constraints for hydraulic function and mechanical strength in plants at high elevations (P <0.05). The strongly limited hydraulic transport system reflected the severe growth constraint of A. fabri at high elevations. Though series of anatomical traits varied with elevation (e.g., smaller mean diameter of tracheid, mean hydraulic conduit diameter and mean pit aperture diameter at higher altitude), thickness-to-span ratio $((t/b)2)$ played a dominant role in the trade-off between hydraulic efficiency and safety. The $((t/b)2)$ was positively correlated with stem hydraulic conductivity but negatively correlated with percent loss of conductivity and water potential at 50% loss of conductivity, and specific leaf area. Therefore, plants with better hydraulic and growth states at low elevations could allocate more resources to building up solid mechanical supporting systems to cope with high wind load, while those at high elevations with terrible growth states and limited hydraulic functions had to invest more resources in leaves under harsh environments. The weak trade-off between hydraulic efficiency and safety could limit the growth and distribution of A. fabri at timberlines; however, global warming trend may facilitate hydraulic transport and benefit plants' growth in the future.

The Supply and Demand of Water-Related Ecosystem Services in the Asian Water Tower and Its Downstream Area: A Multi-Scale and Multi-Scenario Analysis

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Climate change and human activities can have an impact on the supply and demand of water-related ecosystem services (WRESs) in the Asian water tower (AWT) and its downstream area, which is closely related to the production and livelihoods of billions of people. However, few studies have taken the AWT and its downstream area as a whole to assess the supply–demand relationship of WRESs. This study aims to assess the future trends of the supply–demand relationship of WRESs in the AWT and its downstream area. Here, we estimate the supply–demand relationship of WRESs in 2019 using the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model and socio-economic data. Then, we select future scenarios under the framework of the Scenario Model Intercomparison Project (ScenarioMIP). Finally, trends in the supply–demand of WRESs are analysed at multiple scales over 2020-2050. We found that the supply–demand imbalance of WRESs in the AWT and its downstream area will continue to intensify. The area with imbalance intensification was 2.38×10^6 km2 (61.7%). The supply–demand ratio (SDR) of WRESs will decline significantly under different scenarios ($p<0.05$). The Ganges-Brahmaputra, Mekong and Salween basins of the AWT have the fastest rate of SDR decline. The main reason for the imbalance intensification in WRESs is the constant growth of human activities, with a relative contribution of 62.8%. Our findings suggest that in addition to the pursuit of climate mitigation and adaptation, attention should also be paid to the impact of rapid human activity growth on the supply–demand imbalance of WRESs. Reducing the negative impact of human activities on the supply–demand relationship of WRESs is essential to promote regional sustainable development.

The Future Forest Floor: Coupled 21st-Century Climate and Forest Change Project Thermophilization and Homogenization in A Mountain Landscape

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Protected areas are central to global biodiversity conservation, but their future conservation potential is threatened by climate change, increasing disturbances, and legacies of human management. Climate warming is particularly pronounced in mountains such as the European Alps, a plant diversity hotspot with many cold-preferring species. Projecting future change is critical but challenging for forest understory plants, which respond to microclimate conditions mediated by forest structure and composition that may be decoupled from macroclimate change. Here, we coupled climate and forest change using the process-based, forest landscape

and disturbance model iLand in a 20,808 ha Northern Limestone Alps landscape (Berchtesgaden National Park, Germany) to ask: (1) How do understory plant communities respond to 21st-century changes in climate and forests? (2) How important is macroclimate versus forest change in driving understory responses? Stacked individual species distribution models fit with climate, forest, and site predictors (248 species, 150 widely distributed field plots, overall AUC = 0.86) were used with projected climate and modeled forest drivers to predict plant community change. Landscape mean species richness and understory cover declined (-14% and -8%, respectively, by 2100), and warm-adapted species increasingly dominated plant communities (i.e., thermophilization, +15%). Mean plot-level turnover was high (0.63), and on average 30% of all species and 50% of red list species were lost from the landscape. Higher elevations experienced the greatest richness declines, most thermophilization, and highest turnover, resulting in plant community homogenization across elevation zones. Climate change was the dominant driver of changes in richness and thermophilization relative to forest change, but both were important for cover. Even in protected areas, the magnitude of 21st-century change is likely to erode the ability of mountain forests to conserve biodiversity. Considering both climate and forest drivers alters expectations about understory plant community change, with important implications for future ecosystem functioning and services.

Forest Fragmentation Along a Moisture Gradient in Yinshan Mountain of North China: Patterns, Determinants and Scale Effects

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The scale effect of remote sensing data leads to large errors in the estimation of forest canopy coverage in semi-arid areas, which affects our understanding of the relationship between fragmented forest and climate at regional scales. In this study, we took the Yinshan Mountains in Inner Mongolia, China as an example. We developed an automatic classification algorithm using Simple Linear Iterative Clustering (SLIC) and Gaussian Mixture Model (GMM) methods based on Google Earth images to identify forest canopy at the sub-meter scale, and compared the classification obtained with the forest categories from existing global land use dataset such as FROM-GLC10 and Globeland30. Forest canopy data obtained by our method has accuracy close to 90%, compared with which, the FROM-GLC10 and Globeland30 datasets underestimated the forest area by 21.06% and 16.88% respectively. The underestimations mostly concentrated in warmer and drier areas with severe canopy fragmentation and large area of open forest (tree coverage<10%). We found that temperature explained canopy distribution better than precipitation, and that the canopy fragmentation was more sensitive

to climate variations than canopy coverage. With the increase of temperature and decrease of precipitation, forest fragmentation tends to be serious. Especially when summer precipitation becomes less than 300mm, the number of canopy patches increases sharply, while the decrease of canopy coverage tends to be flat. This study provided a method to explore sub-meter canopy patterns at regional and landscape scales, and emphasized the necessity of using ultra-high-resolution images to study forest fragmentation, which can help guide mountain afforestation in semi-arid areas by explaining the relationship between canopy patterns and the environment.

Key words: Canopy fragmentation, Forest coverage, Google Earth images, Scale effect, Semi-arid mountains

Impacts of Logging and Forest Conversion on Soil Microbiome and Ecosystem Functions in High Elevation Tropical Landscapes

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The rapid pace of logging and forest conversion in tropical forests is a significant concern due to its profound and lasting impacts on community structure and functions. While direct relationships between changes in soil properties, such as pH and microbial community structure, are well established, the indirect impacts of these disturbances on soil microbial community structure and functions remain poorly understood. To address this knowledge gap, we examined the effects of land use change on soil microbial diversity and composition along a gradient of land use types in high elevation tropical landscapes in Malaysian Borneo. We investigated old-growth forests (OGF), mixed forests (MF), and agriculture fields (AF), using surface soil to evaluate soil physicochemical and microbial properties (via next-generation DNA sequencing) and standardized litterbags (Tea Bag Index) to determine litter decomposition and stabilization. Our results indicate that OGF sites were surrounded by over 95% forest, while MF and AF sites were surrounded by a mixed landscape of forest, shrubs, herbaceous plants, and barren land. OGF sites had the highest soil organic matter content, greater soil C:N ratio, less acidity, and higher bacterial and fungal diversity compared to MF and AF sites. The MF sites showed an increased abundance of nitrogen-fixing (Bacteroidetes, Elusimicrobia, and Chloroflexi), nitrifying (Nitrospinae), and amino-acid-degrading (Fusobacteria) bacterial phyla, while OGF had the greatest abundance of methanogens (Planctomycetes) and nitrogen oxide-reducing (Gemmatimonadetes) bacteria. AF had a higher abundance of cellulose-degrading bacteria (Ignavibacteriae). Our findings suggest that forest logging and conversion to agriculture lead to declines in soil microbial diversity and shifts in microbial composition and ecosystem functions. These changes in soil microbial communities may have important implications for the sustainability and resilience of these ecosystems and the services they provide to local communities and the global community at large.

Promote Ecosystem Services for Sustainable Development Goals

Promote Ecosystem Services for the Sustainable Development Goals

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Linking natural and social systems, ecosystem services are the basis of sustainable development. Since the adoption of the 17 Sustainable Development Goals (SDGs) in 2015, the SDGs have become a priority for global development. However, existing studies have not yet realized the link between "landscape pattern - ecological process - ecosystem service" and "sustainability" in ecosystem services research. Based on the link between ecological processes and ecosystem services, we conducted a multi-scale ecosystem service assessment based on the cascading relationship of "supply-flow-demand". We revealed the trade-offs and synergies of multiple ecosystem services, analyzed the sensitivity and exposure of ecosystem services under land use change and climate change scenarios, and analyzed the impact of ecological restoration on ecosystem services. In addition, we discussed the impact of ecosystem services on regional sustainable development and its mechanism, improved the research paradigm of "pattern - process - service - sustainability", and proposed the optimal regulation strategy of ecosystem services to promote the progress of the Sustainable Development Goals. Our work provides a key scientific basis for ecological restoration and SDGs-oriented optimization of ecosystem management.

Uncovering Scale Effects on Spatial Patterns and Interactions of Multiple Cropland Ecosystem Services: A Case Study in Eastern Coastal Hangzhou Bay Area, China

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Scale has a pivotal role in shaping ecological patterns and processes, and the features and interrelationships of ecosystem services (ESs) are both affected by spatial scales. Identifying scale effects of spatiotemporal characteristics of ecosystem services and relationships between them is crucial for achieving sustainable management of ecosystems and preserving human well-being, especially for cropland ecosystem with multiple functions closely linked to essential human needs. The primary objective of our study was to strengthen the understanding of the intricate interactions of diverse cropland ESs at multiple scales and to explore the impact of spatial scale on ESs and their relationships over the last two decades. We conducted our study in the Hangzhou Bay area of eastern coastal China to analyze the spatial scale effects and temporal variations of cropland ESs supply, trade-offs/synergies, and bundles based on a multi-scale framework. The results showed that ESs had relatively stable spatial patterns and hotspots during 2000-2019, but converged towards homogeneity and aggregation

as the scales increased. In terms of trade-offs/synergies in pairwise ESs, correlations were stronger and more synergistic at coarser scales compared to the finer scale. Three ESBs were delineated at all three spatial scales, which were relatively consistent in the average characteristics of ESs within them, but spatial heterogeneity and scale effects on their patterns were evident. These findings revealed variability in cropland ESs and their linkages across space and time, and highlighted the significance of spatial scales in studying regional ESs, which could provide an important reference for planners and decision-makers in proposing sustainable management strategies for cropland ecosystems and achieving improvement in multifunctional land use schemes.

Keywords: Ecosystem services; Scale effects; Hotspots; Trade-offs and synergies; Ecosystem service bundles; Cropland

How Multifunctional Are F.Albida Parklands In Senegal? A Landscape Scale Assessment of Multiple Ecosystem Services and Its Impact of Food Security

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Faidherbia albida agroforestry parklands are widespread in Sub-Saharan Africa under 250-600 mm of annual rainfall. Given its potential to provide a large spectrum of ecosystem services (ES) largely displayed in the literature, F.albida parklands are now widely recognised as a promising option to meet the 2030 UN SDGs. However, most evaluations were carried out at the tree scale and a landscape scale assessment of the multiple ES they provide, their interactions and their impact on food security, is still lacking. In this study we benefits from the recent advances in terms of Earth Observation (EO) combined with agricultural field monitoring and households surveys at landscape scale to (1) analyze the multiple ESs supplied by a Sahelian F.albida parkland and their relationships and (2) to scrutinize the direct and indirect contributions of the F.albida parkland diversity to food availability and food access. We evidenced that the majority of ES indicators remained below ES potential values over the study, revealing that there is a considerable scope for increasing the ES supply in the F. albida parkland. We also showed that significant trade-offs and losses (58 % of the area) between ESs can exist in the F. albida parkland. Interestingly, we also showed that synergies occurred mainly up to 10 m from the F. albida trees, suggesting that synergies need to be increased beyond this threshold. Finally we found that F.albida parkland contributed mainly indirectly to household food security through an "agroecological pathway", i.e.by the provision of ecosystem services regulating and supporting crop production. By adopting an original ES valuation framework, we provided basic insights into ESs, their relationships and impacts on food security. The different maps and information generated can support public debates and target new policies fostering the multifunctionality of F. albida parklands as in various other parklands of West Africa.

Healing Community with Nature in the Post Covid Era: Landscape Approaches and Strategies

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In Tar Creek Superfund Site, US, Lead and Zinc contamination is the main threat not only to the natural environment but also to the human livhoods. During the pandemic period, people who live in the community suffered from the surrounding polluted land. It is substantial to building a safer, greener, cleaner environment for native people who live here. methods employed: The project explores microorganisms in biogeochemical cycling and affects both the speciation and bioavailability of metal(loid)s across the long-time scale. Microbes in this Tar Creek extreme habitat as invisible living agencies represent a significant portion of the biodiversity and biomass in soils and play key roles in sustainable ecosystem remediation. It also can reinforce and integrate real experience of nature in the raw to the inhabitants of Oklahoma. The interwoven network envisions to integrate the remnant urban habitats into a system of linked patches that incorporates the 'unseen' components of the eco-system and composes a "dialogue" towards the native land.major result: comphrensive design plan with local community. Conclusion: Based on the topographical condition, the urban context weaves the water system together by applying a subtle bio-infrastructure solution to the existing residential drainage infrastructure, campus rainwater fountain and agricultural drainage outlet, and designing a hydrology plaza for the purpose of flood control and radical remediation and public gathering. The urban landscape filters not only help reshape the chat piles, but also provide an opportunity to imagine a free and safe

Native Plant Selection to Increase Ecosystem Functions in Urban Areas in Tshwane, South Africa

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Climate change and rapid urbanisation create an urgency to establish urban plant species that will adapt to warmer and drier climates. This is important in South Africa, where it has been predicted that the climate will experience increased temperatures and decreased precipitation. With plants serving as a baseline for the attraction and habitat of other species, these plant species must also provide important ecosystem services. Considering what plant species to favour is essential because it can affect the benefits and services landscape designers and planners add through continuous interventions. Through an experimental study, we tested the potential of native grassland plant assemblages to 1) enhance biodiversity and ecosystem functions and services and 2) survive in urban environments. The study, therefore, specifically inquired into the refugium function over two years while monitoring the tolerance of native plant species to urban environments over a six-month period. A quantitative approach was used, with stratified random sampling of insects and plants through pit-fall traps and quadrats with abundance, species richness, Simpson, Shannon and beta diversity

variables and chlorophyll fluorescence testing for plant health with maximum quantum yield and total performance index parameters. The results indicated that diverse native grassland plant selections supported a higher refugia function in urban environments. All native grassland plant species tested for stress tolerance functioned with good photosynthetic health and can be recommended as resilient species that tolerate temperature and moisture extremes. The paper provides guidelines for landscape practitioners regarding plant species selection to increase ecosystem functions and services.

Keywords: Biodiversity, Ecosystem Services, Grassland, Native, Non-native, Plant, Soil, Stress, Tolerance, Urban, Vegetation

Forest-Based Ecosystem Services and Sustainability Transition among Forest Users from the Western Ghats of Maharashtra, India

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Forests from across the globe are getting impacted due to various factors. These factors include the issues formed due to changes in land use policies, deforestation for industrial use and infrastructure development, expansion of village territories and increasing population pressure, climate change and its adverse impacts on forest resources etc. These responsible factors can cause the shrinking of forest cover, alteration of the quality of forest-based resources, loss of habitat for biodiversity and dependent forest users, and disasters like landslides, floods etc. These factors raise concerns over the sustainability of the livelihoods of millions of dependent people. Western Ghats is one of the most sensitive ecological biodiversity hotspots in the World. UNESCO consider the region as one of the World Natural Heritage Site by recognising its importance of forest services. The forests of the region are known for their ecosystem services, such as natural resources, which provide material that could be the basis for income, food, shelter, and medicines to rural households. They serve as a primary source for major rural livelihoods as many indigenous communities depend on forests for meeting their basic needs of fuelwood, fodder, small timber for agricultural tools and house construction and even food and medicines in the form of Non-Timber Forest Products (NTFPs). These products are primarily consumed by the Forest Dependent Communities (FDCs) at the household level, while the surplus products are traded in the local market for additional income. This additional income from NTFPs plays a vital role in the sustainability of the household. The study explains diverse aspects of forest-based ecosystem services (FES) and their role in achieving sustainability among the forest users of the Western Ghats of Maharashtra. The study uses the sustainable livelihoods framework (SLF) to analyse the capital structure of the forest users and also highlights their vulnerability context. We used the cluster sampling technique to select the individuals and interviewed

them using semi-structured schedules. Additionally, the study also uses PRA methods and needs assessment surveys to collect required socioeconomic information from the forest fringe areas of Western Ghats. With case studies, we explain the need for local people's participation in forest management activities to attain sustainable livelihoods.

Keywords: Sustainability Transition, Ecosystem Services, Sustainable Livelihoods, Western Ghats

Re-Evaluating Success in Transboundary Fisheries Management: Pacific Halibut A Case Study

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Transboundary fisheries which span multiple exclusive economic zones (EEZs) are at higher risks for overexploitation currently and at an increasing rate in an uncertain climate future. Furthermore, capture fisheries remain highly inequitable amongst ocean sectors. The shift toward the Blue Economy paradigm as a new model of sustainable coupled human and natural oceanic systems necessitates that modern ecosystem management of fisheries accounts for the cost-benefit sharing of fishery resources required to meet sustainable development goals and build resiliency within management systems. Recent efforts have been made to understand how fishery management strategies affect fishing communities but equity assessments are still missing from many management structures. This study aims to evaluate the equity structure within transboundary fisheries using the Pacific Halibut (Hippglossus stenolepis) as a case study with the explicit goal of assessing the "measure of success" within management strategies. The effectiveness of community participation in fishery management, the utility of quota allocation, and the benefits of community-based research were all evaluated through a methods portfolio approach including a literature review, economic assessment, and seascape ecology analysis. Preliminary results indicate that despite these efforts to boost equity within the fishery, community participation within the fishery has declined significantly over the last several decades as barriers to enter the fishery continue to rise. Meanwhile, the commercial quota consolidation within the fishery has led to a less diverse portfolio of fishers and consequently, a system less resilient to the inevitable disruptions of climate change. These findings highlight the conceptual gap in definitions of success that present a barrier to equity and community inclusion as a fundamental goal of fisheries management.

Key Axes of Global Progress Towards the Sustainable Development Goals

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Identifying the principal dimensions of Sustainable Development Goals (SDGs) is key to measuring the extent to which SDGs are addressing the broader aim of agenda 2030. However, the key axes of global SDG progress over the past two decades remain largely unknown. This study aimed to identify the major axes of global SDG progress and analyze the variation of SDG axes along with their spatial-temporal patterns and in relation to economic status. Principal Component Analysis was used to identify major axes of the SDGs that comprise basic-needs, governance, and higher-needs bundles. The results show that three key axes, viz. resources and ecosystems, the living environment, and well-being and equality, underpin the basic-needs, governance, and higher-needs SDGs respectively. Spatially, highest PC scores for basic-needs are clustered in high income countries, governance PC scores are globally polarized, while the results suggest that higher-needs PC scores are progressing only at a sluggish pace in most countries. In terms of temporal trends, progress has relied heavily on the contribution of basic-needs and governance SDGs. The SDG axes differ by country income levels, although the goals that contribute most to major axes in high-income countries also contribute most to global axes. The identified key axes of SDG progress highlight the necessity to promote the nexus of sustainable food-water-land, resilient cities, health, and equality to implement the SDGs more holistically. The study assists in the identification of appropriate research priorities and in developing more effective transformation strategies towards delivering the SDGs by 2030.

Sea Shore Land Reclamation, a Threat to the Coastal Biodiversity: A Case Study from Mundra Port, India

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The land along the zero line which is the zone connecting sea water line during high tide and low tide. This adjoining zone is very important which connects sea and land, it is verified that the sea animals, Microbes and as well as the various plant species are getting their maximum nutritional energy from this zone. This zone is considered as seashore, mudflat, sea beach areas as part of coastal morphology. The abounded coastal areas are sometime opening the door to industrialization for a nation to strengthen their economy through the construction of ports along the seashore. When land is reclaimed from the seashore then it pulled a coastal ecosystem along with the area which is selected for

industrialization. We had required an industrial setup for developing any kind of industry in the coastal region through destroying the mangroves, sea animals and their habitats. It is a threat to the coastal ecosystem and coastal Biodiversity. In case of Mundra port, which is the largest private port in India, developed by the Adani group and did such a land reclamation processes in Gujarat north shores of Gulf of Kachchh region for industrialization and commercial development. To construct the port, they had destroyed many mangroves areas and impacted the coastal ecosystem on a large scale because of their port area expansion since the year 1998 to till date.

Key words: Land, Reclamation, Coast, Biodiversity, Threatened, Habitat

Ecosystem Service Assessment of Forest Patches in Mosaic Agricultural Landscapes in Cameroon and Benin

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Deforestation remains a major challenge to sustainable land use in West Africa with forests being converted to agriculture and other land uses. However, some forest patches persist in agricultural landscapes but little knowledge exists of what ecosystem services they provide and to what extent despite the degradation and conversion pressure. This study's focus is on forest patches in agricultural landscapes in Cameroon and in Benin. These countries illustrate contexts where land use conversions remain high and the perception of the management of forests is quite different. Through household surveys, key informant interviews and focus group discussions in the communities owning or using the forests, we identify and assess the ecosystem services delivered by the forest patches that are considered as the most important from the local communities' perspectives. The most reported ecosystem services of high importance for communities are provisioning services such as foods, medicinal plants and raw materials as well as cultural services such as the spiritual value of forests and the tranquillity, while rainfall and the fresh and clean air of the forest serve as the main regulating services. Over time, especially within the past five years (2018-2022), those services have reduced drastically to the extent that communities are obliged to go deeper into the forest to collect what they need for their everyday life. Across the cases studied, few alternative sources of income apart from forests have shaped the management of those forests in such a way that it has affected the functioning of forests and their ability to provide ecosystem services. Thus, from communities' perspectives, training on new technics to improve the productivity of their agricultural lands is a solution. In addition, awareness campaigns and reforestation programs were mostly cited as solutions to restore degraded ecosystems.

Demonstrating Education for Sustainable Development through Rainwater Harvesting in Institutions of Higher Learning in Kenya: The Potential at Kenyatta University

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Although Kenya is classified as a water scarcity country, investmnet in rainwater harvesting and storage infrastructure is still low in most households and across public institutions of higher learning. While the initial investment cost may be prohibitive to households, the apparent failure of universities to demonstrate rainwater harvesting from their vast roof catchments (artificial landscape features) remains a moot question. This paper assesses the lost potential in rainwater harvesting potential at Kenyatta University and proposes water stewardship guidelines going forward. Roof-footprints were estimated using Geographic Information System procedures. Analysed rainfall data was obtained from the meteorological station at geography department. Results show that mean monthly rainfall ranged from 15-180 mm, averaging at 75 mm. Further, annual and monthly totals, including rainfall days fluctuate a lot and have been declining since 2005. Most buildings in the university are fitted with rainwater harvesting infrastructure but lack storage tanks. As such all the rain water harvested is discharged as runoff. As an example, on average, the central administration complex forfeits 290,800 litres/month, the Business Services and Student Centre 289,700 litres and the Post-Modern Library 465,300 litres per month. Precious water lost from hostel catchments is much more given their combined roof areas. The economic, social and ecological effects of such wastage cannot be overemphasized. Further, the university undermines its status as a centre of excellence in capacity and competence development in resource use efficiency and education for sustainable development. Through transformative leadership, institutions of higher learning can nurture a culture of water stewardship and demonstrate its importance to both learners and the wider public and thus contribute to the realisation of sustainable development goals.

Spatiotemporal Changes of Watershed Social-Ecological System and Ecosystem Services and Their Relationships: A Case Study in The Jialingjiang Watershed, China

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As a link between the natural and social-economic systems, the spatial distribution characteristics of ecosystem services (ESs) are closely related to the social-ecological system (SES) structure. There still needs to be a greater understanding of the internal relationship between ESs and SES. Understanding their relationship will provide vital scientific support for planning and utilization. The Jialingjiang watershed (JLJW) is an important ecological functional area in the upper reaches of the Yangtze River, China. Six land use types, four typical ESs, including water yield, soil conservation, carbon sequestration, and habitat quality, and statistical methods to explore spatiotemporal changes of SES and ESs and their relationships from 1980 to 2020. The main SES types in the JLJW are farmland, forest, and grassland ecosystems. The comprehensive SES dynamic degree increased from 0.01 to 0.52 in the last 40 years, with a fast expansion of the settlement ecosystem. The water yield services are

higher in the south and lower in the north JLJW. Complex social and ecological factors affected various spatiotemporal changes in the ESs. The water yield of different SES types is the settlement > other land types > farmland > grassland > forest > water area. The soil conservation varies significantly, and the subareas with a high value are mainly in the northwest and east JLJW. Forest, farmland, and grassland ecosystems are the primary sources of soil conservation services. Area increase of forestland into grassland and farmland caused the decline of carbon sequestration in the JLJW. The habitat quality in JLJW is lower except for forest, grassland, and water area. Significant changes in SES happened as economic space expansion, food production space reconstruction, and natural ecological restoration. The SES composition and configuration will lead to ESs changes. SES heterogeneity should be considered carefully by ESs enhancement and management ways.

Keywords: Social-ecological system; Ecosystem services; Spatiotemporal changes; Management countermeasures

Multifunctionality in the Alpine Region: An Ecosystem Service-Based Approach

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Mountain landscapes that are managed to provide several ecosystem services (ES) have the potential to sustain high levels of biodiversity while also meeting multiple human needs. The promotion of multifunctional landscapes has become an important policy target in land management and has gained research traction under the definition of ES-multifunctionality. However, scale dynamics and patterns of ES-multifunctionality remain poorly understood and are rarely integrated into land management and policy recommendations. To address this gap, we used two diversity indices to quantify ES-multifunctionality based on eleven ES indicators at different spatial scales in a case-study region in the European Alps. The approach used captures the diversity of ES provided at plot and landscape levels (α-multifunctionality) as well as unique ES contributions of ecosystems to the regional ES diversity (β-multifunctionality). Results show that ES-multifunctionality generally decreases from low to high land use intensities and increases from high to low elevations. While forest-dominated landscapes are hotspots of ES diversity, the more specialized ES supply in landscapes above the tree line and on valley floors enhances regional ES-multifunctionality. This study highlights how understanding ES-multifunctionality and its incorporation into policy and landscape management requires adopting a multi-scale approach. Plot-scale analyses are necessary to identify the environmental characteristics underpinning ES-multifunctionality with a fine level of detail. However, looking at the distribution of ES at landscape and regional scales uncovers the benefits originating from interacting ecosystems, and can support the

identification of areas that should be protected, restored, or sustainably managed.

Improving Livestock Production Through Urea Treatment of Browse

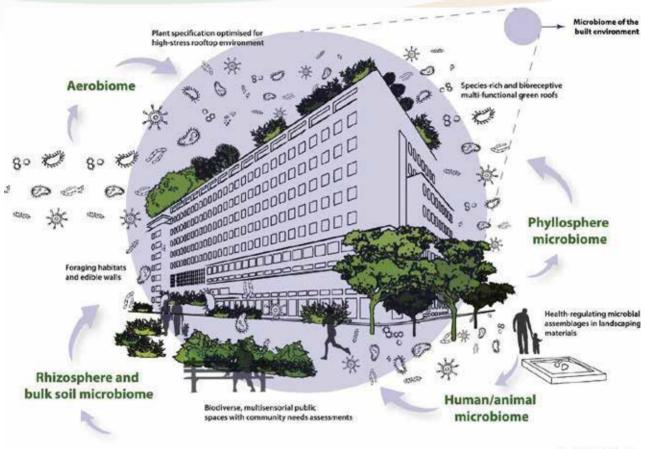C. P. Mudzengi[1,2*], A. Murwira[1], C. Murungweni[3], T. Halimani[4], H. Fritz[5]

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Agricultural production is the main source of livelihoods for people living in semi-arid areasof Southern Africa. However, climate change impacts on rangelands such as reductions in feed availability and quality adversely affect livestock production. Colophospermum mopane is a browse tree species of great significance in these semi-arid areas. In livestock production, for instance, C. mopane persists during prolonged dry seasons characteristic of these areas, abundantly providing highly nutritive browse when the grazing resource is limiting.However, its use is restricted by high condensed tannins. Potential of urea in improving utilization of C. mopane leaves was evaluated by comparing 0, 3, 5, 7 and 9% urea treatment levels. The optimum was 7%. At 7% urea, condensed tannins were lowest while in vitro dry matter digestibility (IVDMD) was highest. At 9% both condensed tannins and IVDMD were insignificantly different from 5% urea treatment. Crude protein increased from 8.4% in 0% to25.4% in 9% urea. Although 7% urea treatment resulted in significantly lower maize stover intake than conventional feeding, it had significantly higher maize stover intake than in unsupplemented cattle. Conventional feeds maintained live weights, while there was a decrease of 8 kg for urea treated dry C. mopane, which was significantly lower than in unsupplemented animals (-21kg). Therefore, 7% urea treatment improves quality of C. mopane, and feed intake and live weights of animals. Increased livestock production can contribute towards achievement of Sustainable Development Goal 2 on zero hunger.

Plant specification optimised for high-stress rooftop environment

Microbiome of the built environment

Aerobiome

Species-rich and bioreceptive multi-functional green roofs

Phyllosphere microbiome

Foraging habitats and edible walls

Health-regulating microbial assemblages in landscaping materials

Rhizosphere and bulk soil microbiome

Biodiverse, multisensorial public spaces with community needs assessments

Human/animal microbiome

Trends in Biotechnology

Publishing and Disseminating Transboundary Landscape Ecology and Landscape Architecture Research: Challenges and Opportunities

Best Practices to Advance the Equitable Publication of Diverse Landscape Ecological Science: Current Landscape Ecology Reports and a Review of Types and Sources of Bias in Editing and Publishing

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Knowledge and innovation thrive in a diverse environment. New ideas, new ways of knowing and doing, and new data from a diversity of sources stimulate the development and testing of existing hypotheses and the creation of novel ways to explain the world. This potential is particularly potent in the global science of landscape ecology, which developed from multiple epistemological traditions informed by varied socio-ecological contexts. In our field, as in others, the influence of diversity on knowledge production is mediated by editors and publication outlets, which play an important role in the dissemination of research and thus, its future directions. The journal Current Landscape Ecology Reports, which publishes short, invited reviews in topical sections, is making global, transboundary research that addresses ecosystem management in the Anthropocene more widely available by publishing the latest advances from IALE chapters and working groups. In 2022, the journal added sections devoted to landscape ecology research from Africa, Russia, Iran, and India. In 2023, it welcomed sections from the Argentina chapter and the leaders of the Forest Landscape Ecology and Urban Landscapes Working Groups, and a new Tropical Landscapes section. This presentation will introduce the audience to Current Landscape Ecology Reports and its editorial practices as well as review the state of the art of how editing and publishing can foster the equitable dissemination of science from a diversity of voices. The review will summarize evidence of bias in scientific editing and publishing and suggest a toolkit of best practices that fosters equity and inclusion.

Publishing Ecological Research in a Digital Era

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Publishing findings from scientific investigations is the most effective method to share advancements among colleagues and with practitioners and policymakers. Over the past three decades, there has been massive growth in the number of published papers, books, reports, databases, tools, white papers, webpages, and personal opinions, and broadcast through such vehicles as blogs and Twitter posts. There are many reasons for this proliferation, including improved education systems, growth in populations and economies, and advancements in computing capacity and information technology. Peer-reviewed publishing outlets are challenged to optimize numbers of journals, their scopes and volumes, styles, management, and speed, while researchers are challenged to select the journal that is most likely to share their research in a timely manner and with the right readership. As a panelist for this session, I will share my thoughts on three topics related to developing manuscripts in (landscape) ecology studies. Journal selection: Though journal impact factor dominates many scholars' decision

making, due to institutional needs, associated policies, and publishing speed. Yet readership and long-term impacts have more influence on authors' professional images and discipline development. Manuscript quality: While digital technology makes distribution of research faster and more effective, manuscript quality is not necessarily higher than it was in the pre-digital era. Often, details are lacking or not formulated with high standards. Common shortfalls include use of vague terms, inconsistent terminology, units, citation/reference bias and imprecision, low quality illustrations and captions, plagiarism, and poor prose. Scientific innovation: A scientific publication should feature some new discoveries, not just technical reports and/or replications of previous work in new landscapes (or of new subjects). A common problem found in initial submissions is that the statistical analysis does not match the experimental design. Descriptive manuscripts are less favored by reviewers, editors, and journals.

Publishing In IALE's Flagship Journal Landscape Ecology and Beyond: Some Practical Recommendations

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Founded in 1987, Landscape Ecology has been the flagship journal of the International Association for Landscape Ecology (IALE) and a barometer of the development of landscape ecology as a research field.

During the past 35 years, Landscape Ecology has published thousands of articles which together document what this interdisciplinary field is all about and how it has evolved over time. In this presentation, I will explain the aims and scope, manuscript handling process, and performance metrics of the journal, with suggestions for improving author success from the editor's perspective. Some recent trends observed in the journal's publications will then be presented, and some "hot topics" will be highlighted. Then, I will address some more general questions on scientific publishing, particularly relevant to landscape ecology. For example, what are some of the efficient, impactful, and responsible ways to disseminate research results? What kinds of papers (article types) should we write to reach our audience or to achieve our objectives? How can we better promote communications among landscape ecologists, landscape architects, and other scientists, all of whom are needed to advance the science and practice of landscape sustainability?

The Perspective of a Community Owned Self-Published Open-Access E-Journal (Landscape Online) - Publishing in the Field of Landscape Ecology

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It has been 15 years by now that the International Association for Landscape Ecology – Chapter Germany

(IALE-D) launched the e-journal Landscape Online. At the time of its first publication in 2007, to the best of our knowledge, it was one of the first open access peer-reviewed scientific e-journals in the field of Landscape Ecology. Over the last 15 years, it evolved from an idea driven by the German-speaking IALE community in Germany, Austria and Switzerland to a wider established journal linked to the international IALE community supported by partners across the world. In this talk, we (1) present the journal's development and the regional distribution of authorships, (2) reflect on the topics addressed by the articles published, and (3) outline the latest developments in the light of continuities and changes. Based on the journals experience we will highlight some challenges and recommendations that we believe are relevant to consider for authors intending to disseminate their work in scientific journals.

Resilience of (Agricultural) Landscapes: How, When, and What to Assess ?

Ecosystem Services and the Resilience of Agricultural Landscapes

Elena M. Bennett[1], Julia Baird, Helen Baulch, Rebecca Chaplin-Kramer, Evan Fraser, Phil Loring, Peter Morrison, Lael Parrott, Kate Sherren, Klara J. Winkler, Jerome Cimon-Morin, Marie-Josee Fortin, Barret L. Kurylyk, Jeremy Lundholm, Monique Poulin, Jesse T. Rieb, Andrew Gonzalez, Gordon M. Hickey, Murray Humphries, K.C. Krishna, David Lapen

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Global social and economic changes, alongside climate change, are affecting the operating environment for agriculture, leading to efforts to increase production and yields, typically through the use of agrochemicals like pesticides and fertilizers, expanded irrigation, and changes in seed varieties. Intensification, alongside the expansion of agriculture into new areas, has increased harvest, but has also had numerous well-known impacts on the environment, ultimately resulting in a loss of resilience and lack of sustainability in agro-ecosystems. Combined with features of agricultural systems such as the differential movement of ecosystem services, and interactions among ecosystem services driven in part by management choices, such intensification has disrupted key feedbacks in agricultural systems. These changes have tended to perpetuate the management choices that have led to efficient, productive agriculture, often at the expense of nature and the provision of important nonfood ecosystem services. Here, we explore how agriculture functions as a complex adaptive system. We assess how recent changes have interacted with agro-ecosystem features to result in a loss of resilience, and suggest key research directions to help harmonize production and ecosystem function, drawing primarily on Canadian examples. Enhancing the resilience of agricultural landscapes is critical to the long-term sustainability of agriculture in a rapidly changing world.

Resilient Agricultural Systems: Robust, Adaptable, Transformable

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The European Commission aims to improve the resilience of European farming (e.g. EU Commision, 2018). According to Meuwissen et al. (2019) a resilient farming system "maintains the essential functions of EU farming systems in the face of increasingly complex and volatile economic, social, and environmental institutional challenges". Agriculture fulfils numerous functions. For example, markets satisfy economic requirements, such as the provision of food and other renewable resources. In addition to this, agriculture also creates by-products that are not remunerated via markets, such as the creation and maintenance of cultural landscapes or biodiversity arising from production. These agricultural functions constitute public goods. However, Feindt et al. 2018 found that the measures of the EU Common Agricultural Policy (CAP) for resilience is largely skewed towards robustness of individual farms, especially in terms of sustainable agricultural incomes and financial buffer against shocks. Such a buffer fails to be sufficient if the framework conditions shift permanently following a shock, with the

result that the system's functions can no longer be sustainably delivered or only on a reduced level. Resilience requires that the system can adapt to an extent that the loss of performance is stopped or limited and the system can recover to deliver its key functions sustainably and to a sufficient extent. If the shocks are so extensive that the system is unable to recover even after adaptation, the question arises as to whether the system can be transformed to enable again the key functions or perhaps even other functions. Therefore, we need to differentiate systematically between robustness, adaptability and transformability when assessing resilience (Meuwissen et al. 2018). In this contribution we discus from an agricultural perspective what resilience specifically means, and whether the resilience of individual producers can be equated to that of the sector as a whole.

Regulating Ecosystem Services Delivered in Tropical Agroforestry Systems

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The growing global population require bold agricultural solutions that provide continuous improvements of farming systems in order to upturn productivity and maintain provision of ecosystem services. Agroforestry has been recognized as an ideal landscape intervention that can provide a variety of ecosystem services with potential to increase agricultural productivity and climate resilience. However, provision of these ecosystem services varies from place to place and there are also trade-offs. It has also been challenging to quantify the benefits from agroforestry because of lack of data and a general focus on provisioning ecosystem services. This study appraises evidence on six regulating ecosystems (soil fertility, erosion control, water regulation, wind regulation, pest regulation and pollination) for which research in the tropics has shown that integration of trees on crop or pasture land can provide significant benefits. The ecosystem services are described, evidence of whether the presence of trees increases the service or not is provided, and factors that affect the provision of the ecosystem service in agroforestry discussed. Generally, agroforestry increases the provision of regulating ecosystem services within the landscape, leading to increased growth and yields from crops and animals. However, there are situations where agroforestry may lead to a reduction in certain ecosystem services, leading to trade-offs. Trade-offs among regulating services and between regulating services and other ecosystem services are for example brought about by competition for resources such as water, nutrients and light, and increases in certain pests. Reducing tradeoffs among ecosystem services remain a challenge that should be addressed by well-designed practices that allow for spatial and temporal complementarity. In view of vegetation diversity and variability of land uses and land management associated with agroforestry, a tradeoff analysis is required to evaluate outcomes agroforestry on ecosystem service and for targeting management interventions that enhance multi-functionality.

Key words: Agricultural productivity, Agroforestry, Ecosystem services, Meta-analysis

Landscape Structure, Landscape Change and Resilience of Agricultural Landscapes: Insights from Woodland Bird Communities in Temperate Southern Australia

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Which characteristics of agricultural landscapes make them more effective for nature conservation, and more resilient to land-use change and extreme events? Does restoration of rural landscapes (through re-establishing vegetation) increase their value and resilience? Agricultural landscapes occupy over a third of Earth's land surface and so answering these questions, together with the capacity to take effective action, will profoundly influence the future for global biodiversity. Over the last two decades, we have employed a 'whole of landscape' approach to test how landscape structure and change through time influence conservation values, especially of bird communities, in the massively transformed, temperate woodland ecosystem of southern Australia. We present evidence for seven key insights from this research. 1) The spatial properties of 'whole' landscapes have a strong influence on conservation values; for example, they explain >70% of the variation in richness of bird communities. 2) The total amount of natural wooded vegetation is a key influence, with richness of woodland birds showing a non-linear (potentially threshold) relationship with landscape wooded cover. 3) Certain landscape features have particular importance: streamside vegetation, with more-fertile soils, contributes disproportionately to conservation values in heavily cleared agricultural landscapes. 4). Agricultural landscapes are dynamic, and vulnerable to extreme events (e.g. drought), but landscapes with key features – especially more streamside and floodplain vegetation – were more resilient. 5). Restoring heavily cleared agricultural landscapes through revegetation helps return species to otherwise depleted farmland, but bird communities of restored landscapes are distinctive and have complementary values for conservation. 6). The value of restored habitats (and landscapes) increases through time: their bird communities become more similar to those of farm landscapes with natural vegetation. 7). Restoration actions of individual landholders are important: their impacts accumulate, and the benefits extend beyond the local property to enhance the conservation and resilience of the wider landscape.

Climate Resilient Agricultural Practices in Mediterranean Agri-Food Heritage Systems: Morocco

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Climate change is a threat not to the environment and agriculture among other climate sensitive sectors. The situation in dire in developing countries characterized by low adaptive capacity and growing human population. Traditional agri-food systems provide an alternative to agricultural models based on maximizing productivity. The systems general support livelihood of

local farmers, providing solutions for climate change mitigation and adaptation, contributing to the preservation of agro-biodiversity and traditional knowledge and cultural identity. This study shares some best farming practices in the Argan tree agro-forest-pastoral system of Ait Souab-Ait Mansour area in Morocco, one of Globally Important Agricultural Heritage Systems (GIAHS) Programmee designated by the Food and Agriculture Organization (FAO). The study employed a a multidisciplinary approach to identify the possible social and environmental shocks impacting agri-food heritage systems in the study area, linking together landscape structure, climatology, socioeconomic factors and biodiversity assessment. The findings affirm that the Argan tree agro-forest-pastoral system proved its high resilience to a harsh environment under water scarcity, risk of erosion and soil degradation through centuries. The livelihood of local communities is directly or indirectly linked to argan trees, but the system also provides other food and by-products to respond to the community's needs: more than fifty plants are cultivated, often on dry-stone terraces, in addition to livestock breeding. In addition, the role of local cooperatives for argan oil production is crucial for women as they can earn a fair salary. The traditional water conservation strategy is an example of adaptation and resilience to environmental harsh conditions and can serve as an example of a sustainable technology to be replicated in other dry agri-food systems.

Landscape Invariants Based on Landsat Multispectral Data

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Invariance in context of stable spatio-temporal structures in a landscape was proposed by V.B. Sochava in 1961. The accumulation of long-term series of landscape observations by means of multispectral imaging made it possible to identify invariants in practice. An analysis of Landsat multispectral measurements from 1987 to 2022 for the southern taiga landscape (Central Forest State Natural Biosphere Reserve, Russia) shows that invariants identified as order parameters primarily determine total aboveground vegetation biomass, the water content in vegetation and soils, and the intensity photosynthesis, i.e. bioproduction process. Methodology is consistent generalization of multispectral data by method of principal components. The proposed scheme for analyzing time series of remote sensing data makes it possible to assess landscape cover at the time of survey with respect to invariants and to identify the main control parameters that determine changes in environmental conditions and self-development of geosystems. The assessment of vegetation and relief contribution to formation of invariants structure was made to reveal invariants physical meaning. The results

showed that relief has little effect on order parameters, and vegetation cover make the greatest contribution to invariant structure formation. Since invariants make it possible to identify the most stationary states, they can be used to solve applied problems in agriculture and forestry, as well as in the assessment of various ecosystem services.

Climate Resilience of Mountain Winegrowing Regions Across Europe

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A substantial portion of Europe's winegrowing regions (~28%) are situated in mountainous areas with distinct environmental and socio-economic characteristics, making them particularly susceptible to the impacts of climate change. So far, however, many studies only focused on biophysical changes, ignoring crucial interactions and trade-offs among other factors, such as legal, human, and financial assets. To address this gap, here we examined the climate change resilience of European MVA by combining multiple indicators related to climate exposure, sensitivity, and adaptive capacity on the regional level. Our findings suggest that MVA face greater exposure to climate change than winegrowing regions outside of mountainous areas, but they also possess a higher adaptive capacity, resulting in an overall lower climate change vulnerability. In fact, due to their varying topographical conditions and broad elevation ranges, MVA have unique opportunities for climate change adaptation. Nevertheless, they also face distinct challenges leading to increased vulnerability levels, such as biodiversity loss, limited access to transportation infrastructure and adverse demographic changes. Ultimately, the vulnerability of MVA to climate change depends on the complex interactions between biophysical, legal, and socioeconomic factors, and neglecting these factors may lead to biased conclusions. Our research can assist decision-makers at all levels in pinpointing climate change hotspots among winegrowing regions, identifying critical adaptation factors, and efficiently designing and directing climate change adaptation strategies.

Adaptive Landscape Agriculture Using Remote Sensing and Climate Scenarios

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In the context of climate change, there is an obvious need to develop a method of adaptive land use management, which includes the selection of crops and crop rotations, agricultural technologies. At present, we are talking about the introduction of such tools at the level of individual farms and enterprises in many developing countries where there are no available long-term agroecological records and information on agroecological conditions in general. The state of the

land can be determined using remote information, but as a rule there is a gap between the results of the such analysis and specific management recommendations that are understandable for the land user and are possible to integrate into actual agricultural infrastructure. This paper proposes a method that combines statistical spatial modeling of agro-ecological characteristics such as nutrient storage, soil properties, etc., based on remote sensing series, climate data and digital elevation models, and converting the results of these modeling into adaptation instructions that match the capabilities of landuser. The basis of the approach is the combination of iterative factor analysis based on remote sensing data and climate data, machine learning methods for landscape properties modelling and the concept of the adaptive landscape agriculture systems developed by V.I. Kiryushin for adaptive recommendations. Statistical modeling made it possible to recognize the main agro-ecological properties with a probability higher than 0.8, as well as to determine the local functional properties (like erosion or hydromorphism) of landscapes and their changes over time. The paper demonstrates the application of the method for territories of various scales - regions on the example of Uzbekistan, individual farms on the example of the southern regions of the Russian Federation.

Interactions Between Agriculture and Ecological Functions of Agroecosystem in Saxony-Anhalt – A Bayesian Belief Network Approach

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Human action driving environmental change remains to be a common global issue. A major challenge of the 21st century is to maintain or even enhance beneficial contributions of nature to a good quality of life, especially in the tension between food production and ecosystem functionality. To date, agricultural resilience has mostly been researched from an economic or farming perspective, but less from the ecological perspective such as ecosystem functions or biodiversity. Therefore, we aim to identify the key indicators for quantifying agroecosystem resilience using a participatory expert modelling approach, specifically a Bayesian Belief Network (BBN). To this end, a qualitative approach was used to interview experts (practitioners, scientists, NGOs from agriculture and nature conservation) for their mental agroecological network of the Magdeburg Börde (Germany). The Magdeburg Börde is a representative example for intensive, large-scale agriculture on highly fertile loess soils under continental climate in Central Europe. We implemented individual and joint BBNs with Netica. The BBN shows indicators of agroecosystem resilience including background key ecosystem functions and biodiversity elements, and critical feedbacks between agriculture, ecological functions and biodiversity of the agroecosystem. We will use the BBN to analyze how changes in the network affect the resilience indicators and thus ecological resilience itself. We expect a focus on soil health, agricultural management and biodiversity as key indicators of agroecosystem resilience, including the corresponding background factors. Building on this, the results of the approach can

be used to guide changes in agricultural management by taking ecological and agricultural resilience into account at large scale and for different world regions.

Supporting Stable Pollinator Populations and Consistent Crop Pollination in Landscapes Under Crop Rotation

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Pollinators experience large spatiotemporal fluctuations in resource availability when mass-flowering crops are rotated with resource-poor cereal crops. Yet, few studies have considered the effect this has on pollinator population stability, nor how this might be mitigated to better support pollinators and crop pollination.We assessed the potential of field boundary features (grassy margins, hedgerows and wide flower-rich margins) to support and stabilise pollinator populations and crop pollination in UK agricultural landscapes under crop rotation. Assuming a 6-year rotation, we used a process-based pollinator model to simulate yearly pollinator population size and predict in-crop visitation rates to oilseed rape and field bean across 117 study landscapes in England, UK, with varying amounts of boundary features. We modelled both ground-nesting bumblebees and solitary bees and compared the predictions including and excluding boundary features from the landscapes. Ground-nesting bumblebee populations, whose longer-lifetime colonies benefit from continuity of resources, were larger and more stable in landscapes with more boundary features.

Ground-nesting solitary bee populations were also larger but generally not significantly more stable, due to their shorter lifetimes and shorter foraging/dispersal ranges.

Crop visitation by ground-nesting bumblebees was greater and more stable in landscapes with more boundary features, partly due to increased colony growth prior to crop flowering. Time averaged crop visitation by ground-nesting solitary bees was slightly lower, due to females dividing their foraging time between boundary features and the crop, but reduced variability meant the minimum level of crop pollination they provided was still higher than without boundary features present. Our study demonstrates that field boundary features play an important role in stabilising pollinator populations and crop pollination in rotational systems. We recommend using combinations of boundary features, accounting for pollinator range when spacing features/rotating crops, and synchronising boundary feature management with crop rotation to maximise their stabilising benefits.

The Resilience of Traditional Agricultural Landscapes Influenced by Political Support Tools Case Study Buzau County, Southeast Development Region, Romania

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Traditional agricultural landscapes (TAL) are examples of resilience of agricultural forms and practices specific to the local landscape, maintained and adapted over time, being characterized by the dynamic interaction between food production and biodiversity, at landscape level. Although there are multiple political and economic directions oriented towards the maintenance of TAL and implicitly towards the conservation of the associated biodiversity, the practice of traditional agriculture in the context of current global pressures implies a difficult approach. The New Common Agricultural Policy for the period 2023-2027 is oriented towards the support of farmers who contribute to protecting the environment. Methodology: As a first step, the research aims to inventory the eligible areas for the practice of traditional agriculture, in accordance with the agro-environmental and climate measures, related to the National Strategic Plan 2023-2027 (NSP 2023-2027), for Romania, in a case study for the South-East Development Region, Buzău County and the delimitation conditions of the respective areas. The next step of the analysis involves identification of the correspondence on the ground of the analyzed areas, using the method of participatory mapping. Finally, the farmers' conception of the existing support mechanisms and the specific requirements, from the point of view of the resilience of traditional agricultural lands, is followed, through the application of a questionnaire and Q-Methodology's statistical analysis.

Result: Compared to previous years, the NSP 2023-2027 brings changes related to the eligible areas related to agro-environmental and climate measures. For the Southeast Development Region, there are situations where the number of eligible administrative territorial units (ATU) has decreased, e.g. P.1: 60 ATU (2014-2020), 53 ATU (2023-2027) or increased, e.g. P.3.1: 0 ATU (2014-2020), 9 ATU (2023-2027), but the delimitation conditions are much more focused and detailed. There is misinformation among farmers regarding the financial benefits they can access for practicing traditional agriculture. Conclusion: In Buzău county, at the local level, there is potential for traditional agriculture. Traditional practices are not properly used due to farmers' poor knowledge of agricultural sustainability techniques. There are farmers who practice traditional agriculture, but who do not benefit from financial support due to misinformation. The resilience of traditional agriculture largely depends on the involvement of farmers, on the awareness of the importance of maintaining a balance between farmers and nature, a task that should fall to the competent authorities.

Integrating Landscape Assessment and Nature-based Solutions for effective flood risk mitigation around Lake Nokoué, Republic of Benin
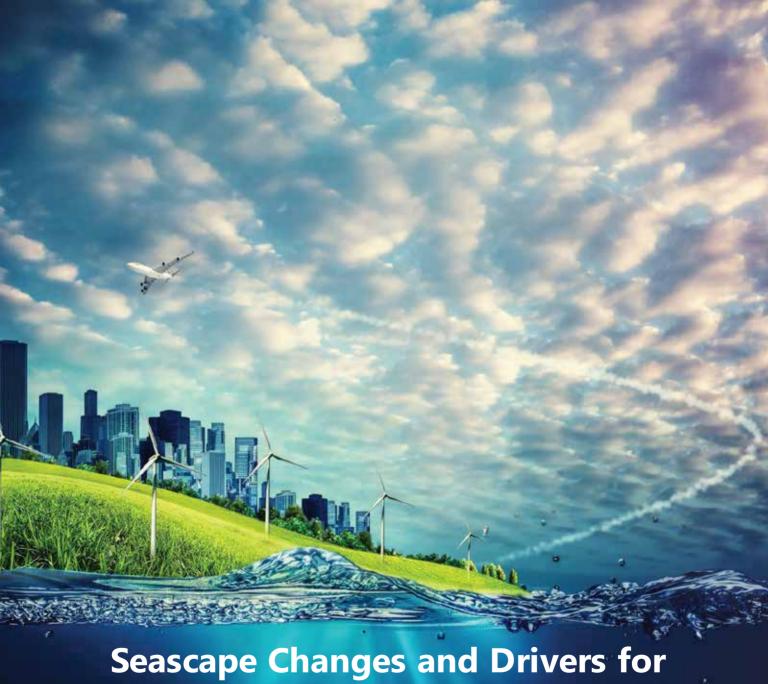
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A well-managed ecosystem has the potential of reducing disaster risk. Located in the southeast of Benin, Lake Nokoué is the country's largest brackish watershed and an integral part of Ramsar site 1018 in West Africa. Rapid and unplanned urban development in the surrounding cities to the lagoon ecosystem raised the risk of flood disasters wider. With the current climate projections showing increased risks of extreme hydro-meteorological events in the coming years, developing new measures for flood mitigation is no longer an option. Nature-based solutions offer a suitable alternative for flood risk reduction with multiple benefits from nature. Using Remote Sensing Data and toolboxes of ESRI ArcMap software, the current research aims to identify and map the potential areas for ecosystem conservation and/or restoration to reduce exposure for the highest number of people. Outputs from the land-use land-cover (LULC) analysis using sentinel data with 10m resolution already showed significant changes between 2017 and 2022. Vegetation and barren land are disappearing little by little to the benefit of agriculture. Further, data on biophysical environment (local site conditions such as slope map, soil type, stream characteristics etc.), planning and governance (land-use land-cover type) and service requirements such as floodplain state and water management will be interpolated to identify potential areas that could reduce flooding through NBS strategies. Therefore, using the final output as a decision-support tool should improve flood hazards that could lead to more resilient communities.

Keywords: Flood Risk Reduction – GIS – Nature-based solutions – Lake Nokoué, Bénin.

Seascape Changes and Drivers for Sustainable Resource Management

New initiatives utilizing seascape in Sanriku Reconstruction National Park in Japan

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In Japan's seacape, the network function of paths and waterfronts that have organically linked natural capital is declining. In addition, public works projects such as the construction of seawalls after the earthquake have created a situation where there are fears of fragmentation of ecosystems and cultural networks. Problems such as the decline of cultural and biodiversity preservation functions have become apparent, and how to properly use and manage seacape has become a major issue. On the other hand, discussions on the use and management of seacape in cooperation with various entities and new mechanisms through networking have deepened, and concrete efforts have been developed through new administrative measures and citizen organizations. In 2012, the Ministry of the Environment formulated the "Green Reconstruction Vision with the Creation of Sanriku Reconstruction National Park at its Core," and in 2013, Sanriku Reconstruction National Park was created. The policy of the trail development was: 1) to establish a long-distance nature trail that "connects" various things such as the local natural environment, local lifestyles, traces of the earthquake, users and local people; 2) to consider using existing roads that were once used for transportation between villages, village roads, forest roads, etc.; 3) to consider using existing roads for the trail development, including roads that were used in the past for transportation between villages, village roads, forest roads, etc. The trail connects villages to villages, the sea to mountains, and other areas, providing a network that supports local culture and a lifeline in the event of a disaster. It is hoped that new value will be added to the network of roads within the framework of the national park, and that recognition by people inside and outside the region will deepen physical and human interaction and improve the resilience of the region.

Integrating Social and Ecological Systems to Address Coastal Vulnerability to Climate Change

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Marine environments are critical in supporting Water-Energy-Food Nexus, and are facing constant pressure from economic development projects and climate change. Coastal ecosystems provide essential Ecosystem Services (ES) on which humans and socio-ecological systems depend for their wellbeing. However, pollution, land reclamation, land use change, and climate change have compromised the deliverance level of these coastal ES. This has resulted in significant impacts on the socio-ecological systems and the coastal communities that depend on these ecosystems. Using the DPSIR (Driver-Pressure-State-Impact-Response) framework, we identified climatic drivers that lead to the alteration in coastal ecosystems and a change in deliverance of coastal ecosystem services. This approach helped establish how an integrated ecological and social system can be useful in understanding the vulnerability of coastal communities, especially fishing

community to climate change. The framework was applied to two local-scale case studies - Mahul and Mahim in Mumbai city - to assess how the impacts of climate change are felt by coastal small-scale fishers subjected to different coastal environmental conditions. This research demonstrates the importance of an integrated socio-ecological system to assess coastal vulnerability to climate change and how this can be applied in the context of the Water-Energy-Food Nexus. By understanding the interconnections between water, energy, and food systems and how they relate to coastal ecosystems and the well-being of coastal communities, we can develop better strategies for sustainable development that balance economic growth, environmental protection, and social equity.

A Biocultural Approach for Holistic Seascape Research, Resilience and Sustainability

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Ecological and natural values of coastal and marine ecosystems interact in a very dynamic process with historical and cultural values. They offer both ecosystem services and cultural services, precious for nature and society. These environments, however, have been strongly impacted over times by human activities and climate change, with traces visible on the land and underwater. Drivers of seascape changes are key for seascape history, the first step towards holistic seascape research. Further steps are nature conservation, society, character assessment, design, planning, policy,

management and governance. The prerequisite is that a biocultural approach is useful to support sustainable seascape design and planning. They in turn assist integrated coastal zone management and participatory development of resilient seascapes.The research is a premise to the work of scholars in seascape studies, published recently in the Routledge Handbook of Seascapes. Linking nature with culture and theory with practice in different continents, their research findings offer opportunities for future conservation and development at multiple scales.

Keywords: biocultural seascape, holistic research, resilience, sustainable resource management, coastal and marine environment and people

Nonparametric Assessment of Mangrove Ecosystem in the context of Coastal Resilience in Ghana

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In this study, geographical data on mangrove ecosystem was quantified, simulated and evaluated using relevant models. The evaluation was conducted with the help of google earth engine (GEE) and InVEST model. The GEE platform was utilized to track changes in mangrove cover relative to other land cover types for the years 2009 and 2019 by integrating synthetic aperture radar (SAR) and optical satellite data. The ecosystem structural aspects such as canopy height and Above Ground Biomass (AGB) density were assessed using GEE for the year 2000 and validated with a field work conducted in 2020. The InVEST model was used to

calculate a hazard index of every 250m of the shoreline with and without mangrove ecosystem. This index demonstrated the role of mangrove ecosystem as a robust nature-based solution to coastal resilience. Between 2009 and 2019, mangrove and other vegetation cover decreased by roughly 16.9% and 21%, respectively. While water bodies and bare/built-up areas expanded by 7% and 45%, respectively. Overall classification accuracy for 2009 and 2019 was 99.6% and 99.1% respectively. Mangrove height and above ground biomass generally decreased from 12.7– 6.3 m and 130– 88 kg/ha on average. The vulnerability index showed that 76% and 23.5% of the coastal segment in the presence of mangrove fall under low and moderate risks respectively. Whereas in the absence of mangrove, 44%, 50% and 6% fall under low, moderate and high-risk zones respectively. Undoubtedly, the study demonstrated that there is the need to enhance conservation practices in coastal management.

Impact of Abandonment and Grazing on Ground Beetle Assemblages in the Baltic Sea Coastal Grassland-Forest Ecosystem

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The main aim of the study was to analyze the impacts of abandonment and grazing on the distribution of ground beetles in the coastal grasslands-forest ecosystems. The study area was located within the west coastline of mainland Estonia (between 57.3° and 59.5° N and 21.5° and 28.1° E) in Northern Europe, covering two different landscape regions. The study included sites managed by grazing and abandoned sites from the margin of the coastal grassland-forest ecosystem. The pitfall traps were used for collecting specimens of ground beetles: four traps in the open grassland, four traps in the forest and two traps in the margin were buried at the ground level in each study site and were left for four effective days in July-August 2021. Ground beetles were collected, stored, and identified at the species level. The data were analyzed in R using a general linear model and ANOVA to compare factors and their interactions, the estimated marginal means for multiple comparisons and the "indicspecies" for species relationships. Results showed that grazing-managed grasslands had significantly higher abundance, species richness, and diversity of ground beetles compared to abandoned grasslands, especially in the Gulf of Livonia coastal lowland region. Indicator species varied by management scheme in both regions. The most common species found in all sites was a large carnivore and a generalist species, Pterostichus niger. Although there were abandoned coastal grasslands with smaller assemblages and less species-rich of ground beetles, the pan-European nature conservation Natura 2000 network and the incentives for land management contribute positively to the species richness of ground beetle assemblages. Our study provides valuable insights into the effects of abandonment on ground beetles and highlights the importance of land

management in maintaining the biodiversity of ground beetles in coastal grasslands-forest ecosystems. However, further analysis of the environmental parameters is recommended.
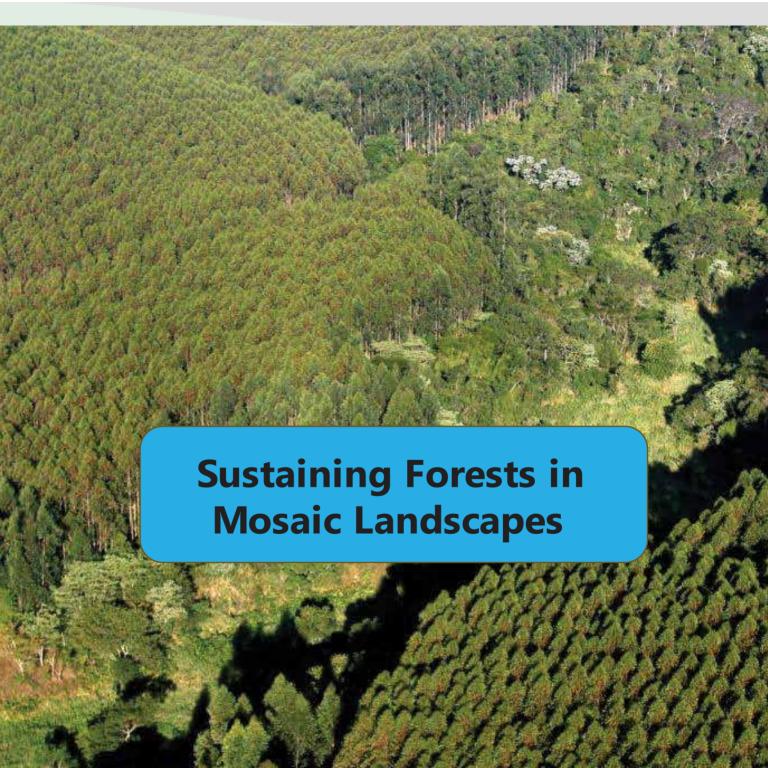
Understanding Cultural Landscapes in the Pearl River Delta: Using Multi-scaled Identification of Landscape Character as a Tool

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Urban deltas have become densely inhabited through the creation of urban centers and harbors throughout history and are now among the most promising regions in the world. However, being the most densely populated part of the world and hardly above sea level, urban deltas are extremely vulnerable to environmental threats with a loss of ecological and social-cultural values. As an extreme case, the Pearl River Delta (PRD) has been the fastest-developing delta in the world for more than 40 years. The interaction of the delta's specific climate and complex water systems with human activities led to the development of a variety of ecologically adaptive cultural landscapes which are experiencing the loss of diversity, sociocultural fragmentation, and loss of spatial identity as well as accelerated processes of physical landscape fragmentation due to environmental threats and the problem brought by administrative boundary controls of the existing planning system. The cultural landscapes are not only worthy of preservation but could also become a basis for sustainable and climate-resilient future development. To guarantee a more sustainable future for the PRD, new types of landscape management processes are necessary that can not only cope with the vulnerabilities but also in enhancing their ability to confront both natural and human-made threats. Therefore, this article uses the framework of Landscape Character Assessment (LCA) to classify landscape characters in the PRD in multiple scales and understand their explanatory factors and relation with the hydraulic society, to propose protection plans and measures for the existing cultural landscapes to stimulate their potential use in future-oriented spatial development.

Sustaining Forests in Mosaic Landscapes

Forest Patches in Urban and Agricultural Landscapes Have Lower Tree Diversity, More Non-Native Trees, And Altered Forest Structure Across Cities and Ecoregions

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Forest patches in urban landscapes make outsized contributions to biodiversity, ecosystem function, and human health and well-being. However, urbanization alters environmental conditions that underpin forest health. To establish whether attributes of forest patches vary with urbanization intensity and other surrounding land cover, and if these effects are consistent across ecoregions, we synthesized tree community composition and structure data from nineteen observational studies (n = 4,905 plots) and remotely sensed land cover across four metropolitan regions (Baltimore-Washington DC, Chicago, New York City, and Philadelphia) spanning five ecoregions of the Eastern Deciduous Forest of North America. This analysis is the first to examine relationships between landscape context and indicators of forest health across intensities of urbanization in multiple regions.We found that ecoregions had distinct land cover signatures and forests were surrounded by heterogeneous land cover, confounding simple interpretations of urbanization, yet general patterns of species distribution and forest structure reflected the influence of landscape context. Forest patches surrounded by high levels of canopy cover had species diversity, tree density, basal area, and size diversity equal to or greater than those with greater agricultural or impervious contexts. In contrast, forests in highly agricultural and impervious settings had similar structure and levels of diversity. Tree species composition varied among ecoregions, yet forests with similar landscape contexts often shared indicator species. Forest structure and tree species diversity in urban forest patches were often more similar to those of forest patches in agricultural areas than to patches in forested landscapes. Lower tree diversity, basal area, and size class diversity combined with greater non-native tree abundance in both urban and agricultural contexts highlights commonalities between these intensive anthropogenic landscapes. In both urban and agricultural landscapes, shifts in forest structure and dampened ecoregional diversity present common challenges to forest health and common opportunities for forest stewardship.

Tree Islands Enhance Biodiversity and Ecosystem Functioning in Oil Palm Landscapes

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In the UN Decade on Ecosystem Restoration, large knowledge gaps persist on how to increase biodiversity and ecosystem functioning in cash crop-dominated tropical landscapes. Here, we present findings from a large-scale, five-year ecosystem restoration experiment in an oil palm landscape enriched with 52 tree islands, encompassing assessments of ten indicators of biodiversity and 19 indicators of ecosystem functioning.

Overall, indicators of biodiversity and ecosystem functioning, as well as multidiversity and ecosystem multifunctionality, were higher in tree islands compared to conventionally managed oil palm. Larger tree islands led to gains in multidiversity via changes in vegetation structure. Furthermore, tree enrichment did not decrease landscape-scale oil palm yield. Our results demonstrate that enriching oil palm-dominated landscapes with tree islands is a promising ecological restoration strategy, yet should not replace the protection of remaining forests.

Recuperation of Piñon-Juniper Woodland Refugia Across the México-United States Borderlands

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Abstract: Persistent piñon-juniper woodlands that signal refugia are found where local soils, climate, and disturbance regimes create favorable conditions for survival and regeneration. Life history traits of border piñon (Pinus discolor) indicate co-evolution with infrequent fires but built infrastructure and intensive land use in the México-United States borderlands disrupt natural patterns of burning. These local effects on fire characteristics occur in a global context of runaway changes in size, frequency, and severity of wildfires that defy projections. Our objective was to determine where woodland refugia may need recuperation, distinguished by collaborative efforts to recover or regain ecosystem functions, including fire, essential to plants, wildlife and people in the borderlands. We modeled piñon refugia using field observations of piñon presence and absence (n = 1202), topographic metrics, seasonal greenness, and bioclimatic variables. We then examined relationships between model predictions, piñon traits and spatial and temporal patterns of recent fires (1985 to 2017) using visualizations and flexible modeling techniques. Piñon refugia were linked to drier aspects at lower elevations corresponding with lower spring greenness (generalized boosted regression mean AUC > 0.8). High predicted values for refugia were located on mountain ranges along and just south of the border. Complex shapes, shifts in timing and orientation of fires were more pronounced in areas closer to the border relative to more remote areas. Piñon refugia remained unburned in some locations, a possible indication of infrequent fire congruent with piñon life history traits. However, we observed low to mixed severity fires within piñon refugia on several mountain ranges. In areas of piñon mortality, recuperation will involve wildlife, plants, and people due to the reliance of piñon regeneration on seed dispersal by birds and the value of pine nuts to local communities. Collaborative efforts of people with diverse cultures and values will be essential to success.

Perceived Benefits from Mosaic Landscapes Across North-Eastern Europe: What Matters and for Whom?

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Agroforestry landscapes are an example of mosaic landscapes that comprise a mix of different land use-land covers including human managed and natural ecosystems. These landscapes are crucial to human wellbeing; however, they are in sharp decline across Europe. Improved understanding of the complexity of agroforestry landscapes within different biophysical, social-cultural, economic and governance contexts is essential for designing effective policy and management interventions that are more tightly aligned with societal expectations and aspirations. This study identifies and compares values that people attribute to agroforestry landscapes across North-Eastern Europe, using case studies in Sweden, Latvia, Belarus, and the Russian Federation. We apply the multiple-value approach developed for the conceptual framework of the Intergovernmental Platform on Biodiversity and Ecosystem Services to an assessment of agroforestry landscapes. Using data from a total of 1634 face-to-face structured interviews, we (i) analyse and explore the preferences of diverse groups of respondents for agroforestry landscapes; (ii) identify a broad range of nature's contributions to people (NCP) that were attributed to agroforestry landscapes by respondents; and, (iii) analyse values of agroforestry landscapes across different contexts in North Eastern Europe. We found that a highly heterogenous group of people – broadly irrespective of age, education, gender, place of residence, as well as political, economic, or social-cultural context – perceive agroforestry landscapes to be important to their quality of life. Respondents attributed multiple NCP to agroforestry landscapes, and non-material NCP are the most frequently assigned in all four countries. An absolute majority of respondents across all case studies considered relational values of agroforestry landscapes to be important for their quality of life with identity as the most often associated with agroforestry landscapes. We discuss how relational values might be incorporated in policies and practices related to mosaic landscapes in North-Eastern Europe.

Conservation Through Conserved Community Areas in A Mosaic Landscape- A Case of the Tangkhul Naga Tribe, Northeast India.

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The Tangkhul Naga tribes are native to the foothills of the northeastern Himalayas of India and reside scattered within the biodiversity hotspot of the Indo-Myanmar boundary. The community under study practices shifting cultivation in a mosaic landscape of agricultural land and fallows, forests, and settlement areas. Within this mosaic, Community Conserved Areas (CCAs) are an eco-culturally established form of natural forest conservation among the tribe. Almost every village has two major types of conserved areas-a greenbelt ('Uyok' in the local dialect) around the settlement areas and full-fledged conserved areas without defined boundaries. Under the common

resource regime, the traditional local institution known as the 'Hangva' or the Village Authorities (VAs) have managed and governed these conserved areas. The study highlights the opportunities and challenges of scaling these conserved areas to contribute to the national climate action targets by increasing green cover, given that northeast India has 64 per cent forest cover. In addition, the livelihood opportunities provided by the conserved areas to the tribals through unaccounted ecosystem services are explored. The methods of focus group discussions with the VAs across five sample villages and in-depth interviews of key informants (local practitioners and government officials) were used to collect data. The study comes out with three crucial and synergistic findings. It was, firstly, understanding the local perspective of multi-functional landscape management and the unique natural resource governance system of the VAs. Secondly, recognise the region's political ecology that involves complex state and non-state actors for effective multi-level governance of the conserved areas. Thirdly, the need for an ecosystem services valuation framework tailored to the study area's context entailing the community's well-being and economic capacitation through these conserved areas.

Invasive Forbs in Savanna and Woodland Herbaceous Stratum as Overgrazing Impact Due to Traditional Livestock Herds in Sudanian Region of West Africa

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Traditional livestock herds foraging in natural rangelands is typical of the Fulani socio-linguistic group in West Africa. In the context of demographic growth and global changes, such uncontrolled use of forage resources leads to overgrazing, the reduction of forage biomass and forbs invasion. Based on diachronic data collected in 1998 and 2020 on savanna and woodlands grazed by traditional livestock herds in Sudanian region of West Africa, this study aims to (i) assess the variation of grass and invasive forb biomass and (ii) estimate changes in the frequency and cover of life forms and chorological types. Phytosociological relevé and biomass quantification were undertaken in 60 square plots of 100 m2 in 1998 and 2020 within the Wari Maro Forest Reserve. The total biomass of grass forage and invasive forbs as well as the spectra of life forms and chorological types were computed on data recorded at the two dates. Findings showed an overall decrease in the total biomass of the herbaceous stratum from 4.47 t DM/ha to 4.09 t DM/ha. The biomass of forage species and invasive forbs followed an opposite trend. The forage biomass decreased from 4.29 t DM/ha to 1.12 t DM/ha while the biomass of invasive forbs, dominated by Chromolaena odorata and Hyptis suaveolens, increased from 0.18 t DM/ha in 1998 to 2.97 t DM/ha in 2020. The relative contribution of grass forage species to the total biomass of the herbaceous stratum decreased from 96% in 1998 to 27% in 2020. However, the weight of invasive forbs increased from 4% to 73%.

So, chamephytes and pantropical species became the most frequent and dominant life form in the herbaceous stratum of Sudanian savannas and woodlands. A reduction of herds size and ecological restoration of rangelands are crucial options for ensuring traditional livestock breeding and its subsequent services.

Analysis Of Forest Governance Arrangements and their Impacts on the Persistence and Transitions of Forests in The Tropics

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Forests (patches) in formally unprotected areas have received limited research and policy attention despite their contribution to livelihood sustainability and global environmental health. Embedded in a traditional social system and used as a common resource, changes occurring in the norms/rules, values, and institutional organization associated with such forests, offer implications for their sustainability outcomes. While the extant literature has predominantly focused on forest degradation and depletion, there is scattered evidence of forest persistence and re-emergence among such formally unprotected forests. However, there is a dearth of knowledge about what governance arrangements influence such forest persistence and transition – often overlooked in forest transition research - despite the surge in reported anthropogenic pressures and climate change concerns. Using a systematic literature review and an empirical case study from West Africa, this study highlights key governance factors that drive forest resilience in the tropics. Through adopting a Social-Ecological Systems framework, this study will respond to the questions: What recurrent types of governance arrangements influence forest persistence and transition in tropical forest regions? What are the impact pathways that explain why forests persist or (re) grow? What sustainability outcomes emerge from such forest governance practices? Initial findings show the traditional notion of "community forest management" may be oversimplified considering the diversity of governance arrangements implemented at the local level. The findings indicate a hybrid scheme of forest governance, where customary institutions are reinforced by external actors and collaborative arrangements. Further, through a process of adaptive maintenance of cultural identity and religious-based stewardship, forests have survived degradation pressures. Findings from this study will inform policy strategies for sustainable forest management and restoration of ecosystem services towards the attainment of SDGs 13&15 in the tropics.

Landscape Context for Forest Transition Success in Central Panama

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Secondary forests are frequently re-cleared before they can recover to pre-disturbance conditions. The

identification of factors associated with passive regeneration persistence success would help planning cost-efficient forest restoration.

In this paper we investigated the role that the landscape context of naturally regenerated forest patches plays for their chances to mature and persist in time in central Panama. Maturation and persistence of secondary forests are concepts often undervalued representing, however, essential requisites for an effective and long-term restoration of the ecosystem processes. Methods: A unique data set of land-cover maps of central Panama was used to identify the forest patches that naturally recovered and persisted between 1990 and 2020. We developed a Random Forest Classification (RFC) calibration method to identify areas with higher likelihood of forest persistence success. Results: The RFC model discriminated between areas that naturally recovered and persisted in time and areas that did not persisted with an error rate of 2%. By tuning, we obtained a precision of 0.94 (94%) in the validation test. Based on the model, we developed a prediction map of central Panama areas with higher probability (≥ 90%) of secondary forests persistence success within the next 20 years. Conclusion: Tracking simple landscape and socio-economic metrics allowed for a deeper understanding of the underlying mechanisms of secondary forest persistence in central Panama. Through the development of RFC calibration method, this study maximized the reliability of the patches identified as suitable to persistence success, representing a basis for management decisions and future investigations for a successful, long-term forest-landscape restoration.

Multi-Decade Study of Changing Landscapes in A Diverse, Agroecological Context: The Case of Nigeria from 1986 – 2022

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Multidecadal timescale assessment of land system change is still grossly lacking in many regions, especially in the tropics. This study leveraged the use of the multi-temporal Landsat image archives of 37 years analyse land use-land cover change in Nigeria, an ecologically diverse context. Analysis was conducted during three-time intervals (that is, 1986/1987 – 2000/2001, 2000/2001 – 2013, and 2013 –2022). The aim is to better capture the impacts on land use from economic reforms and/or changes in policy directions such as orienting agriculture towards export as little work has yet been done for these periods. Land change accelerated during the first and second intervals (that is, 1986/1987 – 2000/2001 and 2000/2001 – 2013) than during the third interval (2013 – 2022). This land transformation due mainly to increased socioeconomic activities was largely driven by the trade liberalization policy during the 1980s and 1990s which favoured export crops. For example, cropland expanded almost two-fold between 1986 and 2022 (22% to 35%). Tree-covered areas and wetlands decreased from 57% to 32% and 6% to 3.7%

respectively between 1986 and 2022. Evaluating results across the different agroecological zones reveals that multiple land change trajectories occurred. losses were mostly due to conversion into croplands In the Rainforest, Mangrove, Freshwater swamps and Guinea savannah, cropland and settlement expanded mostly into tree-covered areas and wetlands, whereas in the Sudan and Sahel savannahs, cropland expanded mostly at the expense of grassland and wetland. This study provides the longest and most current assessment of changes to land use systems in Nigeria. Thus, we provide insights into the spate of land transformation since the end of the 20th Century.

Monitoring Changes in Nigerian Afromontane Mosaic Landscapes with Satellite Remote Sensing in Google Earth Engine

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The Afromontane ecosystems of North Eastern Nigeria are situated on a chain of volcanic highlands extending from the North West of Cameroon to the Gulf of Guinea with altitudes ranging from 800 to 2430 meters above sea level. The ecoregion is recognised for its unique biological and ecological diversity. Owing to its strategic locations, the Afromontane highland uniqueness characterised by all-year-round humidity which makes it a veritable habitat for endemic flora and fauna and also a provider of livelihoods through cattle ranching and other agricultural activities. These series of anthropogenic activities have fragmented the once luxuriant forest ecosystems into highly diverse mosaic landscapes of different ecotypes, namely; forests, riparian forests, agriculture, and Afromontane grassland landscapes. The study uses times series Landsat images of the years 1992, 2001, 2011, and 2022 to discriminate the Afromontane into various mosaic ecotypes using in-situ data with random forest (a machine learning algorithm) in Google Earth Engine. Results from the analysis indicate a gradual shift of changes in the landscape from forest to fragmented forest patches, riparian forest, agriculture, and Afromontane grassland ecotypes. Trajectory change detection analyses of Landsat images (1992, 2002, 2012, and .2022) indicated a decrease in forest cover by, 13% between 1992 and 2002; 18% between 2002 and 2012; and 26% between 2012 and 2022. The overall accuracy of the change map derived from the error matrix was 93% (c. 2001-2022 change map) and 97% (c. 2011-2022 change map). The riparian forest has however been preserved because of its propensity to provide a year-round source of water for the inhabitants, their live stocks and irrigation activities. While the expanding grassland is a result of its source of folders for the ever-increasing live stocks.
 Keywords: Afromontane, Google Earth Engine, Machine learning, Mosaic, Remote Sensing.

Cotton Cultivation Alters the Trois Rivières Forest Reserve into Fragmented Landscape in Northern Benin

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The rapid increase in population, the unbridled search for fertile agricultural land without acquisition costs, and the promotion of the cotton sector through various kinds of subsidies change the forest and savannah landscapes. The Trois Rivières Forest Reserve in northern Benin experienced a rapid transformation of its natural vegetation cover to a fragmented one. This study aims to assess to what extent agriculture, mainly cotton cultivation transforms and impacts the resilience of natural forest and savanna patches in the landscape. To achieve land-cover/land-use dynamics, the landscape composition of this protected area was determined by classifying Landsat ETM+ 2005 and Sentinel 2020 satellite images. The cover of the cotton area was estimated by drone technologies in sampled agricultural lands. The transition matrix and landscape metrics allowed reporting the landscape's degradation state. The results showed that the landscape of this forest reserve has substantially changed with a significant loss of natural classes and a tendency towards their fragmentation. Indeed, the natural land cover (forests and savannahs) which represented the landscape matrix in 2005 (92 % of the total extent) shifted to only 53 % of the landscape in 2020. Moreover, according to the spatial transformation decision tree algorithm, all the natural classes (gallery forest, dry forest, woodland, and savannahs) underwent suppression during the conversion process. Agriculture is the main cause of this loss increasing from 7 % in 2005 to 46 % in 2020. In particular, cotton production is a major driving factor, covering 50% of the areas converted to agriculture. Forest restoration and the retreat of agricultural settlers to mitigate the negative effects of deforestation are major challenges.

Variability Of Spatio-Temporal Vegetation Change in Severalthree Satoyama Hamlets in Japan

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The satoyama landscapes are the most important semi-natural landscapes in Japan. However, these landscapes have been abandoned by changing resource utilization use and social structure in rural areas since the 1960's. I present examine that the method of comparative approach for satoyama vegetation among a number of numerous rural regions in Japan. I showed discuss two satoyama regions—, Yamada (, Saitama Prefecture, Eastern Japan) and Uyama-naka, (Hiroshima Prefecture, Western Japan). This paper also I revealed vegetation changes using GIS by by analysing the multi-temporal vegetation maps made by created with aerial photographs. Before the 1960's, the total each

vegetation areas by vegetation type hads not changed by vegetation type, but the largest area of large change occurred among grasslands and pioneer pine woodlands. They It can be said that the traditional woodland uses were continueding until this period. In Yamada, where was located sericulture region, the mulberry fields turned into became woodlands or grasslands between the 1960's and 1980's. In Uyama-naka, the planting of cryptomeria and cypress trees alteringed secondary pine woodlands was were prominent in same period at this time. The aActive anthropogenic alteration was remarkable at this time. In both regions, the active alteration calmed downlessened in the 1980s. As the vegetation changes along the succession series became were widely seen, it seems that the secondary succession due to stoppage and abandonment of land use became progressive. They are were affected by depopulation and the out flow of successors ofto agriculture.

Vegetation-Human Interactions in the East-European Forest-Steppe Over the Holocene

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East-European forest-steppe ecotone was inhabited and actively used by people since Palaeolithic. During the Holocene, the land use dynamics of the ecotone was changing from forager communities to nomadism and agricultural societies. Around 7.3-7.2 kyr BP Neolithic revolution reached the western part of the region and was spreading eastwards for the next ~2 kyr. Unique position of the forest-steppe at the junction of two different natural zones allowed the coexistence and interchange of cultures with different types of economy, and each of them impacted the landscape differently.

In 2013 we obtained Omelchenki sediment core (Kharkiv region, Ukraine) from the southern border of the East-European forest-steppe ecotone. Nine radiocarbon dates insured the robust age-depth model. Palynological, non-pollen palynomorphs', macroremains', charcoal and loss-on-ignition analysis allowed us to reconstruct the vegetation and fire dynamics due to the climate and human impact over the last ~9.4 kyr BP. Using the modern analogue technique, we reconstructed the forest cover of the area. We conclude that the Holocene climate and environmental changes supported the changes in subsistence bases throughout the Holocene. Thus, in the first half of the Holocene the fluctuations of the southern tree line correspond with the changes of the cultures with forager economies. The mid-Holocene spread of steppe promoted stock breeding as a basis of the Copper Age cultures' economy. The early late-Holocene increase in available moisture and the following forest spread contributed to the transition from nomadism to farming. Our data highlight a high sensitivity of forests in their southern limits to anthropogenic pressure, which emphasizes the possibility of their potential spread further south. However, considering the current global warming the southern tree line is likely to shift northwards bringing the area to the mid-Holocene conditions increasing risks for agriculture.

Theoretical and Practical Relevance of Landscape Fragmentation Metrics for the Moscow Region Forests

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The study of spatial structure of the vegetation cover involves an assessment of the spatial pattern and fragmentation. Numerous studies confirm the influence of landscape fragmentation metrics on the ecosystem functioning parameters such as the species diversity, ecosystem resilience, species migration and gene flow. Current study is aimed at identifying factors of spatial structure of forest cover in the Moscow region and at assessing the potential for using mosaic metrics in protected area management and plannin. The forest cover of the region is considered in the form of hierarchical system of typological units (ecological-phytocenotic classification). Forest ecosystems of the region are heterogeneously fragmented under the influence of the anthropogenic factor since the end of the 20th century. We used a database of 1600 geobotanical field sampling plots and Senstinel-2 mosaic to perform supervised classification and to map forest formations. The methodology was based on quantitative metrics of landscape fragmentation. Patch density, area and perimeter, shape index, fractal dimension, core area index, similarity, proximity and other metrics have been calculated. Forest patches grouped into formations were the subject of fragmentation analysis. We performed correlation analysis between geobotanical parameters collected in situ on the one side and landscape fragmentation metrics obtained for patches where geobotanical data were collected on the other. Significant ($p < 0.0005$) ccorrelations of moderate magnitude are found between proportions of ecological cenotic groups and similarity ($r=0.24$), distance ($r=0.21$), proximity (0.2). We also tested the appearance of metrics for different forest formations by ANOVA. It is found that boreal forest forests are less fragmented compared to nemoral and broad-leaf forests. We propose the technique for implication of fragmentation metrics into process of regional ecological network planning. Landscape fragmentation metrics are found as powerful tool for analysis of regional forest vegetation structure and for protected area management and planning.

Choose Your Neighbour Wisely: A Multispecies Occupancy Analysis of Tiger, Leopard, and Hyena in a Dry Deciduous Ecosystem of the Central Indian Landscape

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Interactions between species can influence their distribution and fitness with potential cascading

ecosystem effects. The recovery of apex predators in Panna Tiger Reserve (PTR), central India, is a success story. Focusing on restoring the top predator requires information on how resident co-predators may interact with the reintroduced species to alter their habitat use and food.

We assessed occupancy patterns and interactions among three carnivore species in PTR; this ecosystem is ideal for assessing intraguild interactions and serves as a guide for reintroduction elsewhere.

We used camera trap data from two seasons to assess occupancy and co-occurrence.

Mean occupancy was highest for hyena (Ψwinter:0.79, 95%CI: 0.74-0.82; Ψsummer:0.77, 95%CI: 0.70-0.81) and leopard (Ψwinter:0.73, 95%CI: 0.68-0.77; Ψsummer:0.70, 95%CI: 0.63-0.74) and lowest for tiger (Ψwinter:0.49, 95%CI: 0.43-0.54; Ψsummer: 0.42, 95%CI: 0.34-0.50). We found differences in predictors for carnivores' co-occurrence between seasons. We observed all three species' high conditional occupancy probabilities when another species was present. Leopard-hyena has shown high conditional occupancy, followed by tiger-hyena and tiger-leopard. Our result indicates a distinct change in occupancy probability across the season. The occupancy and interaction were less during summer due to limited resources. Being a scavenger, hyena preferred to interact more with leopard than tiger in terms of sharing food.
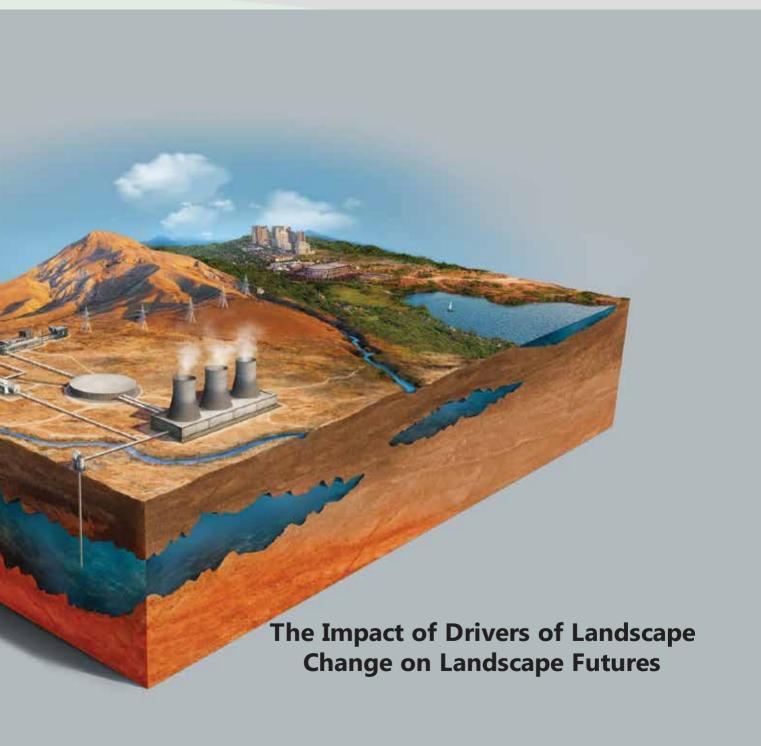
Terrestrial carnivore recovery efforts are ongoing worldwide. Insights into interspecific interactions among large carnivores are critical when considering reintroduction for endangered species. Our study showcases that apex carnivore coexistence is possible with due protection and optimal habitat.

Internal Structural Features of Urban Green Space Affect Biodiversity: A Study on Bird Composition in Multi-Functional Campus Green Spaces

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Building urban green spaces (UGS) is a major way to prevent biodiversity degradation in urban areas. However, apart from landscape-scale environmental factors (i.e., area), little is known about the effect of UGS internal structural features on species composition – both overall and seasonal – especially in multifunctional landscape areas. These may affect the accuracy and universality of results and lead to failure of UGS quality improvement targets proposed by the Kunming-Montreal Global Biodiversity Framework. This study mapped bird distribution hotspots and explored the impact of landscape-scale and internal structural features on bird composition, including overall and seasonal variation, in the multifunctional campus UGS. We documented 69 species and found that hotspots were not only concentrated in specific green spaces, but in specific locations. Bird community composition was influenced by both landscape- scale and internal structural features, increasing with the increase of woody food-source plant richness and shrub evenness, but decreasing with the increase of tree coverage, artificial grassland and ground coverage. Bird distributions were also affected by habitat characteristics at both scales in different seasons. Residential and winter- migratory birds were affected by

physical habitat characteristics. Passing migrants were related to the vertical structure of multilayered vegetation, positively correlated with natural grassland coverage, ground richness, shrub coverage, and tree richness. Our findings suggest researchers and practitioners should consider function and their corresponding site-scale internal structure to improve UGS quality, including food sources, shrub evenness, and vegetation vertical structure, rather than focusing solely on tree or artificial grassland coverage for local biodiversity.

The Impact of Drivers of Landscape Change on Landscape Futures

Integration Of Landscape Services into The Conceptual Framework of Landscape Planning

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The concept of landscape services is attracting more and more attention in landscape planning. Compared to ecosystem services, landscape services play a more significant role in relation to space, culture and the relationship between people and nature, and can therefore serve as a better guide to landscape planning practice. Objectives: This paper proposes a conceptual framework for landscape planning that is based on landscape thinking. It seeks to promote the integration of landscape services into current practice and advocates the use of landscape character as a conceptual tool throughout the landscape planning process. Methods: The literature review supports the revision of existing open issues related to landscape services and their integration into landscape planning. A posterior reflection of the current state-of-the-art was then used as a basis for developing the landscape planning conceptual framework. Results and conclusion: The framework is based on the landscape as a composite system (nature system - culture system - human being) and is articulated around four stages (landscape characterization, landscape service assessment, landscape planning and landscape governance). The framework emphasizes the important role played by people in the landscape and the exploration of ways to sustainably enhance human well-being without damaging nature. As a result, the framework seeks to enhance landscape planning practices by: (i) considering more of the relationship between humans and nature in landscape planning; (ii) making it the baseline of landscape planning not to damage the character of the regional landscape; (iii) using landscape character units as units of landscape governance; and (iv) helping all stakeholders in landscape planning to understand landscape services terminology.

Understanding Community Resilience as a Driver of Landscape Change

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Community resilience represents a complex set of strategies implemented and redefined over time that operate at different temporal and spatial scales. It could be described as a seamless socio-environmental becoming that produces its effects on space and people according to vastly different trajectories, depending on the context and actors involved. Community resilience mirrors the implications of local context in social, political, and environmental terms. Consequently, in the perspective of the increased unpredictability of risky events related to climate change, this mirroring process is potentially undermined, and the impacts in terms of landscape change are even more relevant. This contribution aims at understanding the role of community resilience strategies as drivers of landscape change. The analysis will consider the impacts that development projects enhancing community resilience

may produce in terms of landscape change. In order to work in this direction, the research intends to: (1) analyse the concept of community resilience, and in particular its meaning and adoption in territorial analysis; (2) then, adequately operate the concept in the context of rural communities which have experienced disruptive phenomena ascribable to climate change, such as those living in Arid and Semi-Arid Lands (ASALs) of Kenya; (3) finally, investigate community resilience practices – already implemented or planned – that produce landscape change in the frame of specific local development projects.

This reflection will support a better understanding of how to design policies promoting community resilience that consider landscape change implications.

Keywords: Community Resilience, Landscape Change, Development, Climate Change.

The Landscape Legacy for Sustainable Future

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Landscape is still changing and its present appearance mirrored the past development and is a base for the future. Some landscapes have changed radically, e.g., urban sprawl, open mines or collective open fields. In the other landscapes, the traces of the historical land use and land cover (i.e., historical landscape structures) are still clearly visible and the landscape legacy is more or less preserved. The paper focuses on the fact how the landscape legacy (namely material) could support landscape sustainability and how incorporate it to the landscape planning. Several case studies from the Czech Republic will be presented.

The paper will be divided to several parts. First, the paper focuses on what is the landscape legacy, if there is one or more legacies and present different types of the historical cultural landscapes that could be distinguished in the central Europe. Second, the methods how to identify the landscape legacy and its material traces will be presented. Some methods are based on the data mining of the geographical databases, others supposed terrain research. Third, based on the model areas examples, the paper deals about the sustainability of historical cultural landscapes and how the presence of the historical landscape structures will increase biodiversity. It was proved that landscape structures established in the past and with time and space continuity could serve as refugias for plant and animal species as well as natural habitats. Finally, the paper will shortly present how to incorporate the knowledge about landscape legacy to the landscape planning and scenario planning with the aim to increase both, landscape sustainability and human well-being.

Caught in the Middle: Which Way for the Mighty Baobab?

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Apart from being a part of the ecological landscape, the baobab is also an integral part of the spiritual landscape for communities living along the East coast of Africa.

Due to their very long-life spans, these giant trees have become permanent features in many farms and villages and its products constitute a large component of local diet. There are many rituals and religious ceremonies associated with the baobab in a region that has had nearly a century of Christian based institutions. This co-existence of Christianity and traditional beliefs is an intriguing one, but it looks like Christianity might be winning. Changing traditions and beliefs are putting the baobab in danger as its importance diminishes. But it is the recent reports that baobabs are being uprooted and exported that puts perspective on how much has changed in the last several years, and sheds a spotlight on the fragile nature of the belief system that has for several hundred years helped to preserve these mighty trees. In this paper I examine the factors contributing to the change of status of the mighty baobab, and reflect on the consequences resulting from the loss. The methodology employed is a review of secondary literature supplemented by informal conversations with residents in Kilifi.

Envisioning Rural Landscape in the Digital Age: Digital Agriculture and Landscape Change

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Information and communication technologies (ICT) have changed significantly the way of production and agriculture is no exception. A variety of digital technologies have been integrated with the farming process to increase resource/labour efficiency and reduce the negative impact on the environment. Such practices have been labelled as 'digital agriculture' or 'smart farming' and different countries and regions have been developing policies to facilitate the digitalisation of agriculture. Existing research has mainly focused on the socio-economic and environmental impact of digital agriculture, while few have studied this issue from a landscape perspective although the landscape is an essential part of human beings' surrounding playing a significant role in sustainability. Since the previous waves of technological advancement in agriculture have left an indelible trace on our rural landscape, it raises the question of whether the digital revolution in agriculture we are currently experiencing will have similar effects, causing landscape change. On this account, this article aims to understand the relationship between digital agriculture and the rural landscape by examining the existing literature, focusing on if and how the adoption of digital technology in farming influences the rural landscape. The review concludes that not only the implementation of digital technology but also the anticipation for a digitalised future influences the rural landscape, in a both direct and indirect way. As a consequence, landscape policies and plans should consider this trend of digitalisation as a possibly contributing/risk factor to fulfil the goal of protection and enhancement of landscape values.

Keywords: digital agriculture, smart farming, rural landscape, landscape change

Landscape History as Basis for Possible Future Development in Szigetköz (Hungary)

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Szigetköz is situated along the Hungarian-Slovakian borderline, shaped by the Danube River and its tributaries. The landscape is dominated by arable land with significant proportion of forest covered protected areas along the Danube River. Intensive agricultural utilization, urban sprawl are the most threatening processes in the territory nowadays. In order to better understand these ongoing processes and be able to determine landscape quality objectives for future development strategies, it is advised to analyse the past of the landscape, which can be followed through historical maps and current land cover databases. Military maps from years 1784, 1840, and 1953-59 were used to derive historical land cover information. Maps were vectorised according to a category system containing 20 land cover types relevant to this area. As recent land cover maps CORINE land cover databases from the years 1998-99 and 2018 were used. According to the map series the territory faced remarkable land cover/land use changes during the last two hundred years. Expansion of arable land (from 43.9% to 58.8%) and built-up areas (from 1.1% to 13.1%) and shrinkage of grasslands (from 37.1% to 4.2%) were identified as main land cover changes. These processes show significant intensification of the landscape, which needs to be managed by suitable planning instruments. Among possible solutions extensive agriculture, slow tourism, protection of remained natural areas and reasonable management of build-up areas can be mentioned.

Mapping and Assessing the Changing Risk of the Cultural Landscape of Lushan National Park and Its Fringes from an Integrated Ecological and Social Perspective

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As a World Heritage Cultural Landscape, the traditional landscape of Lushan National Park's fringes is in rapid decline during China's rapid urbanization. it is essential to systematically identify and assess landscape change to ensure a stable continuation of cultural landscape diversity and identity. This study analyses the integrated assessment from both ecological and socio-economic perspectives. Firstly, we use landscape metrics to indicate the change in landscape pattern based on the land use data of 2000, 2010 and 2020. Fragstats was used to calculate the landscape metrics for each stage, including PD, LPI, LSI, AI and SHDI. Secondly, the socio-economic development intensity (SEDI) was calculated through economic density (GDP of the towns), road density, population density, impermeable surface area and landscape development intensity, etc. The indicators are calculated by AHP hierarchical analysis and visualized in a GIS.The relationship between the landscape metrics and SEDI was analyzed through a

bivariate spatial autocorrelation model in GeoDa software, divided into "high-high type", "high-low type", "low-high type" and "low-low type". The relationship between the landscape metrics and SEDI was clustered in three-time series: 2000, 2010 and 2020. Based on inductive from the literature, the clustering diagram can be divided into three levels: (1) high risk, namely, scenarios with increasing SEDI and decreasing landscape patterns (decreasing landscape density, diversity, aggregation and other indicators). (2) medium risk, namely, scenarios with decreasing SEDI or no significant change and decreasing landscape patterns. (3) low risk, namely, scenarios with or without significant changes in SEDI and increasing landscape patterns (increasing landscape density, diversity, agglomeration, etc.) or without significant changes. By analyzing changing risks of the cultural landscape, it is possible to implement a holistic landscape protection and management strategy in both Lushan National Park and its fringes.

What Drives Coastal Imaginaries?

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In coastal landscapes human infrastructures are feistily met with nature's testing abilities. Yet coastlines are one of the most attractive living environments where populations tend to flock up. What does the future hold for the maritime landscape: built-up areas, nature-based solutions or virtual reality? This presentation will introduce the results of a scenario study that was devised before COVID-19 and conducted during the pandemic. The irony of course lies in the fact that when picturing the darkest possibilities, e.g. closing of borders and cessation of international travel we could not really imagine the scope of it. As per Hobbs (1997) the future is something we are making, the brainstormed scenarios were elaborated with the help of students and coastal schoolchildren and inhabitants before sociologically representatively tested on both coastal communities and enterprises. The presentation will take a look into the methodology of scenario-building on economic pressure and environmental restraints axes along long and short text writing across 10 topics as well as using real photos to produce composite artistic image and its development into four different futures of: "A. Fast forward – excitingly", "B. Place-based vacation", "C. Virtual lenses" and "D. Patchwork of restrictions". In the end we will contemplate on the usefulness of using young people in scenario studies and the role of NIMBY and climax thinking in climate change.

Post Disciplinary Approaches and Landscapes of the 'Fifth Wave': The Development of Policy for Future Landscapes

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The struggle to find more sustainable futures for major societal and environmental problems is faced globally

at all levels in societies and communities, although it is clear that vulnerable people, landscapes and countries are and will be affected most by the major problems we all face. Increasing urgency for action is encouraging decision-makers to see that this is a critical time to develop novel approaches to landscape policy, planning and management. While the term landscape approach has been used for some years, with notable exceptions (e.g., Sayer et al 2012) the application of the concept is not well explored. Landscape approaches could drive change for significant impact. Such change needs to be considered as potentially transformative for both landscapes and communities – that is a change that makes things better. In 2021 a team of researchers was commissioned to examine how new landscape approaches and future options could respond to the need for novel development of landscape policy for England. This paper reports on the process of negotiation and development of proposals for policy that emerged. Landscape approaches provided the starting point towards achieving common ground for partnership-building for policy-makers, scientists, practitioners, and for achieving meaningful engagement with other stakeholders and communities. Post-disciplinary exploratory working catalysed the development of different ways into the same problem to understand values, problems and potential processes for policy development. The research revealed the need to tap into different types of knowledge(s) and understandings and to work across different administrative levels and landscape scales. The importance of providing new ways of framing solutions and visions – of a 'fifth wave' of change - for decision-makers may be as important as the solutions themselves in order to build enthusiasm to persuade politicians who are the arbiters of financing for landscape change through policy implementation mechanisms.

Public Perceptions and Landscapes Changes in Cairo

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The city of Cairo has been witnessing mega infrastructure projects that are imposing various changes on the urban landscape of the city. The infrastructure projects include roads widening, bridges, and numerous traffic mitigation solutions. The massive waves of trees cutting associated with these projects resulted in tremendous impact on city's landscape, people's daily urban behaviours, and most importantly people's environmental interactions and perceptions. This research is looking into people's reactions to these changes in relation to their perceptions on trees importance. The research is utilizing social media as a digital platform for people's reactions and perceptions. Understanding people's perceptions about landscape challenges is crucial for drawing the future. balancing people-nature relationships in relation to people's needs and quality of life is very important in big cities like Cairo, which necessitates a better understanding of the context socially, ecologically, economically, and politically.
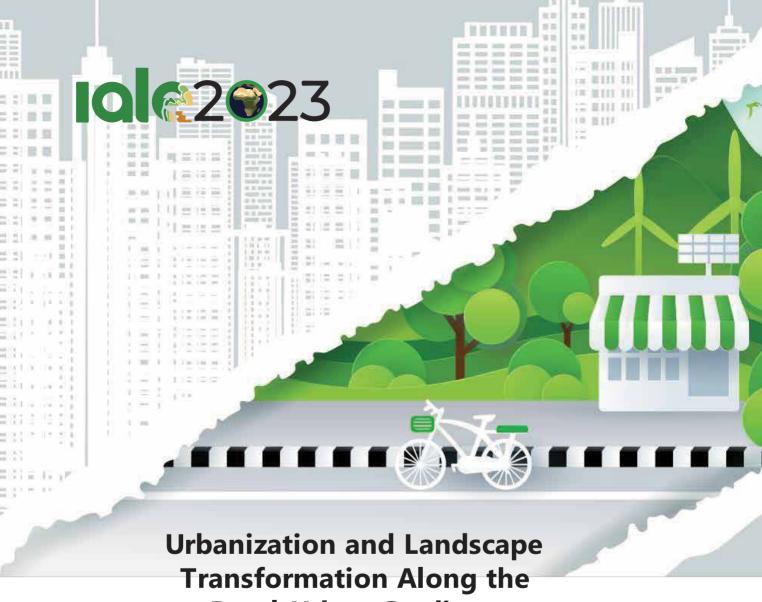
Biodiversity and Climate Outcomes of Alternative Global Trade Scenarios

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Achieving a sustainable future requires an agricultural production goal that accounts for the growing global population and addresses the loss of biodiversity. While trade can connect countries with agricultural production deficits and surpluses to alleviate hunger, the international flow of commodities and agricultural expansion pose significant threats to wildlife and the climate. To tackle these challenges, we used scenarios modelling the land use change consequences of commodity trade expansion and retraction, along with ambitious conservation and restoration efforts, and estimated the impacts on biodiversity and climate change by 2050. Our findings suggest that although trade expansion scenarios negatively impact biodiversity and emit more carbon than business-as-usual projections, capping the trade of commodities and forcing localized production does not improve biodiversity outcomes. This indicates that there is an optimal level of trade that can spare land for conservation. Latin American countries, home to biodiversity hotspots, disproportionately suffer the consequences of trade expansion. However, expanding protected areas and restoring degraded land in this region can offset the negative impacts of trade on biodiversity and carbon emissions at the global level. To ensure a sustainable future that reconciles food security, biodiversity conservation, and climate stability, we recommend a mix of trade liberalization facilitation policies and ambitious conservation and restoration initiatives. By demonstrating the interplay between trade and conservation, our findings can provide novel insights to support policymaking. Balancing the benefits of trade with the need to protect biodiversity and mitigate climate change impacts is critical, and our study highlights this importance.

Urbanization and Landscape Transformation Along the Rural-Urban Gradient

Changes Of Urban Buildings Along the Urban-Rural Gradient Based on the 3D Reconstruction of Urban History by the Time-Series Landsat Imagery

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The urban landscape is involved in both the two- and three-dimensional (2D and 3D) geospatial characteristics of the built-up environment. For a long time, a large number of studies on spatiotemporal patterns of urban landscapes worked in the horizontal dimension but ignored the changes in the vertical dimension. The major reason is the historical data for quantifying the vertical structure is not available most of the time. Here, we presented a new approach for 3D reconstruction of urban history based on the long time-series Landsat imagery and the building footprint with floor information. This approach first detects the building age for each contemporary building by change detection based on the long-term observations from Landsat time-series imagery. The current information on building high is then transferred to the building with ages for generating the historical 3D maps. We then applied this approach to characterize the urban 3D structure and its change along the urban-rural gradient from 1986 to 2017 in Shenzhen, a megacity in China. We found that: 1) the overall accuracy for building location change was 87.80%, and for building age change was 77.40%, suggesting the integrated approach provided an effective way to collaborate the horizontal (i.e., building footprint) and temporal information (i.e., building age) with the vertical (i.e., building height) on generating the historical data for urban 3D reconstruction. 2) The number of buildings increased dramatically from 1986 to 2017, by eight times, with an increased proportion of high-rise buildings. 3) Although two new centers clustered with high-rise buildings emerged, the urban 3D structure still showed a spread with a decrease in building height and density along the urban-rural gradients.

Keywords: urban landscape, vertical dimension, building age, spatiotemporal pattern

Spatial And Temporal Dynamics of Land Use/Cover and Landscape Structure Changes in the Czech Republic Over the Last 30 Years

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Dynamics of land use/land cover transformations have led to extensive landscape changes in many parts of

Europe, directly affecting ecological landscape functions and processes with far-reaching consequences for biodiversity and natural resources. Therefore, the knowledge of changes in land use/cover and landscape structure is a fundamental part of planning for sustainable development. The European and international trends in land use/cover change are caused by urban sprawl, afforestation, deforestation and extensification or intensification of agriculture. Similarly, these processes have shaped the landscape pattern within the last three decades, the most intensively in the Czech Republic. In many regions, arable land and mixed agricultural systems were replaced mainly by extensive grasslands and plantation forestry; however, many areas were strongly affected by urbanisation. Over the last three decades, there has been an increase of more than 300 km2 in urban areas, mainly at the expense of the most productive agricultural soils directly impacting landscape functions (soil production, soil water retention, biodiversity etc.) and landscape heterogeneity. The landscape structure has also undergone dramatic changes in the past. The socialist collectivisation in the second half of the 20-century simplified landscape structure as parcels of arable land were unified to the requirements of heavy machinery. The second event came with the fall of the Iron Curtain resulting in a new widespread modification of land use/cover hand in hand with the transformation of landscape structure due to the restitution of private ownership. However, the agricultural land still consists of large unified fields. Most agricultural land is concentrated in a relatively small number of large parcels. Over half of the total agricultural land area (52 %) comprises land fields of over 40 ha, with the average size of these blocks being almost 80 ha. This has

negative consequences, i.e. soil erosion, soil water retention and biodiversity and the landscape in the Czech Republic, in light of climate change, is facing many challenges.

Settlement Systems Along the Rural-Urban Gradient in Eastern Africa and Europe

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Settlements systems can be conceptualized along a gradient from villages to metropolises. Along this gradient, systems differ in their land cover, their population, and numerous other properties. The distribution of settlement systems can have important implications for land take, and urban sustainability broadly. Yet, we know very little of this distribution beyond the arbitrary division into urban and non-urban. Here we map settlement systems along the rural-urban gradient for Eastern Africa and Europe in 2015. Subsequently, we analyze these maps in terms of the distribution of total land area, built-up land cover, and population. In terms of total land area, we find that Deep rural (i.e., no built-up land present) is the predominant class in Eastern Africa, while slightly more than half of the land surface of Europe is characterized as Isolated villages. Not unexpectedly, urban systems make up a very small fraction of the land in both regions, and this fraction is much smaller in Eastern Africa than in Europe. More interestingly, we find a rather contrasting distribution of people over settlement systems. In Europe, Large cities, Urban landscapes, and Dense

villages contain the largest number of people, while in Eastern Africa the vast majority of the population lives in Deep rural areas and Isolated villages. Furthermore, we find that the population density is more than three times as high in Eastern Africa as it is in Europe, for all settlement systems. As a result of this, population densities in towns in Eastern Africa is even higher than that of large cities and urban landscapes in Europe, on average. These findings provide the much-needed nuance to the traditional rural-urban divide, and suggest the need to go beyond land cover mapping and towards landscape characterization of human settlements.

Estimating Impacts of Urban Expansion in Metropolitan Regions: An Ensemble-Based Land Use Modelling Approach for the R Environment

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The Madrid region, capital territory of Spain, has long been a hotspot of urban expansion in Europe. Though the Great Recession and subsequent European debt crisis (ca. 2007-15) led to a well-documented collapse of the real estate market, the Madrid region has seen strong economic recovery and its population is predicted to grow by > 1 million by 2037. Such rapid population growth puts Madrid ahead of all other Spanish autonomous regions except Catalonia (which is far larger). This projected population expansion, together with the region's past history of land liberalisation for the real estate market, its laissez-faire approach to development control, and the increasing preference for dispersed, low-density development, suggest that Madrid is likely to see very significant urban growth in the next decades. Previous research into urban expansion in the region has generally been limited to analysis of past changes or projections of a general nature that tend to follow a single scenario trajectory. Little attention has been paid to the widely diverging possible urban futures in the region, the potential for different development patterns, or the relationship between urban land and population. In this paper, we explore these aspects through an ensemble-based approach using the freely-available SIMLANDER model running in the R environment. We discuss the impact of the projected development under the different simulation ensembles for key indicators (CO_2 emissions from buildings, loss of agricultural land, loss of natural land etc.).

Assessment Of Physical Quantity and Value of Natural Capital in China Since The 21st Century Based on a Modified Ecological Footprint Model

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Although the ecological footprint has significantly contributed to sustainability evaluation for many years, the traditional ecological footprint model is limited by lack of value accounting, incomplete account content, neglect of multi-functions of land, and geographical spatial heterogeneity. These limitations reduce the universality of this model. To improve the value accounting of the ecological footprint model, this study takes national hectares (nha) as the measurement unit and includes the freshwater and pollution footprints. The dynamic changes of natural capital from 2000 to 2018 were calculated and analyzed in 31 Chinese provinces. The main findings are summarized here. China's physical quantity of ecological footprint, ecological carrying capacity, and ecological deficit in 2018 was 4.03, 0.79, and −3.24 billion nha, respectively. The energy account contributed most of the physical quantity in the ecological footprint (72.12% of the total). From 2000 to 2018, the physical quantities of the per capita ecological footprint and the per capita ecological deficit increased at 5.49% and 10.08% per annum, respectively, while the physical quantity of the per capita ecological carrying capacity decreased by 0.55% per annum. By 2018, China's ecological footprint, ecological carrying capacity, and ecological deficit were valued at 18.09, 12.44 and CNY −5.65 trillion, respectively. Over the 2000–2018 period, the per capita ecological footprint and ecological carrying capacity increased by 495 and CNY 370 per annum, respectively, while the per capita ecological deficit expanded at CNY −125 per annum. The biological account contributed approximately 59.53% of the value quantity of the ecological footprint. The most ecologically challenging regions in China are Shanghai, Tianjin, and Beijing. In contrast, Jilin, Qinghai, and Tibet impose low ecological pressure in China. These findings contribute to the standardization and localization of the ecological footprint model in China and provide a reference for regional resource management and ecological construction.

Contextualizing household food insecurity: A case study of Ambrose, Alfred Nzo district and Maramanzhi, Vhembe District, South Africa

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Smallholder crop production is a defining feature of achieving food security, particularly at household level. However, the area of land where cultivation is practiced in rural areas of South Africa is declining as households withdraw from field cultivation to home-gardening. While substantial efforts have been devoted towards assessing food insecurity in the country, the need to increase productivity for rural households demands attention. The paper will present results from a study conducted to determine the prevalence of household food insecurity in two villages, each located in Eastern Cape and Limpopo provinces. Semi-structured questionnaires were administered to acquire both qualitative and quantitative data from 106 household heads. IBM SPSS Statistics 28.0 computer programme was applied to complete data analysis. Findings of the study, analyzed through the Household Food Insecurity Access Scale (HFIAS) indicated that food insecurity is a

prevalent phenomenon among households as majority respondents were mildly food insecure due to food shortages emanating from insufficient income and waning crop production. Low income coupled with social grant dependency has negative implications for household food security but crop cultivation is adopted as a vital strategy for alleviating food shortages. Since deagrarianization erodes opportunities of increased smallholder production, enhancement of cultivation needs to be central to policies addressing food insecurity. In this regard, interventions extending beyond the provision of water, electricity, market access, skills and information could not only improve self-provisioning capacity but also make the prospects of achieving household food security feasible.

Keywords: cultivation, deagrarianization, food security, rural households, smallholder farmers

How Do Ecosystem Services Supply and Demand Evolve Across Urban–Rural Transitional Landscapes: Patterns, Trade-Offs, And Drivers

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In complex social-ecological systems, both human well-being and the sustainable development of society ultimately depend on ecosystem services (ESs). Integrating both supply and demand of ESs into ecosystem management is an essential way to maintain regional sustainability. Taking Beijing-Tianjin-Hebei urban agglomeration as the case study, the spatiotemporal patterns of ESs were assessed by using biophysical spatially models. Their trade-off relationships and drivers were also explored by using correlation analysis and geographically weighted regression, respectively, thus to understand the spatial heterogeneity along urban-rural transitional landscapes. The results showed that urban and urban-rural fringes expanded by 315% and 305%, respectively, over the past four decades. Most of ESs supply indicators showed exponential functions and were the highest in rural areas, except for food production and water purification. The average values of ESs demand were highest in urban areas, except for soil retention. Most of ESs were deficits and they were the most serious in urban areas, except for recreational service. The trade-offs and synergistic relationships between most ESs supply and demand were most obvious in rural areas. The correlations between the supply of provisioning services and regulating services were positive in urban areas, while they changed into negative in rural areas. Most of ESs demand showed positive correlations, while soil retention with other ESs showed negative correlations, especially in rural areas. As the scale expands, the influence of socio-economic factors decreased, while natural factors showed a turning point. GDP and population density mainly affect urban areas, while climate factors and slope mainly affect rural areas in the southeast, and vegetation covers significantly affects rural areas in the northwest. Finally, the ecological priority restoration areas in urban-rural landscapes were also designed and planned by considering ecosystem service deficits and trade-offs.

Keywords: *Ecosystem services; urban–rural landscape; deficits; trade-offs; drivers*

Policy instruments for sustainable peri-urban futures: Towards governance mixes

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Peri-urbanization is a process of anthropogenic transformations of landscapes located beyond urban fringes and is characterized by extending urban fabric on unbuild and unsealed areas. It leads to emerging of unsustainable peri-urban landscapes (PULs), composed of a fluid mixture of natural land covers/uses and artificial areas.Our research goal is to collect case studies and experiences of spatial planning-oriented policy mixes. A policy mix is not an unstructured combination of different policy instruments (PIs); but it is a thoughtful mix of various types of PIs and policy support tools and methodologies. To implement our research, we designed an on-line survey which allowed us to describe different policy mixes in 50 case studies PULs around the globe. We investigated what kind of PIs, policy support tools, approaches and methodologies have been implemented and combined to address specific planning challenges in the extent of PULs.Our results show that most of the policy PIs adopted so far in peri-urban contexts are legal or regulatory instruments. Mixes of PIs typologies have been frequently adopted to address different peri-urban challenges. Frequent combinations are the association of "planning and zoning" and "strategies and actions plans" or "binding legal and regulatory instruments". PIs in peri-urban contexts usually try to achieve multiple objectives. The regional level plays the most important role in terms of both scale of cooperation and direct funding. In most of the cases, representatives of the civil society and the economic sectors have been at least consulted, but involvement of individual citizens rarely go beyond information. Barriers related to implementation of PIs in peri-urban contexts relate mostly to the lack of financial resources, followed by issues related to governance fragmentation and coordination between policies and instruments that address different aspects of a PUL. Finally, based on the outcomes of our research, we discuss the novel concept of governance mixes, which go beyond existing policy mix compositions for PULs.

Roads and Traffic: An Important Telecoupling Between Urban and Rural Areas

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Roads and traffic can have strong negative impacts on the environment, ecology and human health and well-being. Especially in rural areas, where roads traverse more natural areas, their ecological
and environmental impact can be significant. As traffic volumes on rural roads are largely determined by the population density and economic conditions in urban areas, rural roads form an important telecoupling between urban and rural areas. However, due to a lack of large-scale road traffic datasets, it is difficult to determine the magnitude of the impact of rural roads

and their traffic on their surroundings. In this study, we assessed the development of the area of land that is influenced by rural road traffic at a global level and compared that to the area of sealed road surface. To do this, we first created a global time series of traffic volumes (i.e., Annual Average Daily Traffic; AADT) on all highways, primary roads and secondary roads outside of urban areas. For each section of road, we calculated the size of its "road effect zone", which represents the land that is strongly influenced by pollution and disturbance of traffic and is proportional to the traffic volume. We found that in many countries the area of sealed surface by roads is dwarfed by the size of the road effect zone, which can cover a considerable proportion of a countries surface. As expected, we found that the AADT on rural roads was strongly influenced by the population density and economic conditions in a country. These findings highlight the importance of considering road use rather than road surface when assessing the impact of roads and traffic in rural areas. We emphasise that when assessing the ecological and environmental impacts of population growth and urban expansion, the impacts of rural roads and traffic should not be ignored.

Impacts of Urban Expansion on Vegetation in Drylands: A Multiscale Analysis Based on the Vegetation Disturbance Index

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The rapid urban expansion in drylands has threatened local fragile vegetation in recent years. Evaluating the urban expansion impacts on local vegetation in drylands effectively is crucial for promoting regional urban sustainability. Taking the drylands of northern China (DNC) as a case, we quantitatively evaluated the positive and negative urban expansion impacts on vegetation using the vegetation disturbance index. The results indicated that DNC experienced significant urban expansion from 2000 to 2020. The urban land in DNC expanded from 8141 km2 to 27787 km2, an expansion of 19646 km2, with an annual growth rate of 6.3%. The negative urban expansion impacts on vegetation far exceeded the positive impacts. Urban expansion negatively and positively affected 8448 km2 and 2643 km2 of vegetation, respectively. The former was 3.2 times that of the latter. Further, we applied the random forest model to identify which environmental and socio-economic factors shaped the different impacts of urban expansion on vegetation in the DNC. The negative impacts on vegetation are mainly caused by the conversion of agricultural and natural ecosystems to human settlements. The positive impacts may be a result of the cultivation of green space, which is the achievement of greening policies, such as regular irrigation, fertilization, and development of bare land. Therefore, cities in drylands should balance urban development and vegetation conservation by strictly controlling cropland and grassland occupancy and expanding urban green infrastructure.

Keywords: Drylands; Urban expansion; Vegetation disturbance index; Vegetation conservation; Sustainable development

Investigating the Vertical Distribution Patterns of Urban Air Pollution Based on Unmanned Aerial Vehicle Gradient Monitoring

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Abstract: Understanding the vertical distribution patterns of air pollution is crucial to elucidate the formation mechanism of extreme air pollution events and explore the air pollution exposure risks of residents. The vertical air pollutant (SO_2, NO_2, $PM1$, $PM2.5$ and $PM10$) concentrations along a west-east sampling belt of 0-120 m height were investigated using a multirotor unmanned aerial vehicle (UAV) equipped with mobile sensors on 4 monitoring days. Vertical distribution patterns were explored by ordinary least-squares regression and Pearson correlation coefficient. The results indicated that the concentration of particulate matter decreased gradually from west to the east (S1 to S8) on monitoring Days 2 and 3. The ground cumulative effects of atmospheric particulate matter ($PM1$, $PM2.5$, $PM10$) were significantly higher than those of gaseous pollutants (SO_2, NO_2). The vertical variation ranges of pollutants from large to small were $PM10$ ($k = 0.18$), $PM2.5$ ($k = 0.16$), $PM1$ ($k = 0.07$), NO_2 ($k = 0.06$) and SO_2 ($k = 0.01$). Atmospheric particulate matter tends to change significantly with vertical height, and the concentration decreases gradually with increasing height. The proposed UAV based gradient monitoring approach and vertical pollutant change trend analysis

method could promote the urban air pollution researches and urban sustainable development.
Keywords: UAV; Particulate matter; Gaseous pollutants; Sampling belt; Urban environment

Urbanization and place attachment along the rural-urban gradient of Budapest Metropolitan Region

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Negative effects of rapid urbanization process are recognizable in peri-urban areas. Several researchers highlight that more attention should be paid to peri-urban ecosystem services in order to elaborate the most effective resource management and policies to decrease the negative demographic and land use impacts. Among these ecosystem services related research, the cultural ecosystem services (CES) are the most neglected types. In order to deal efficiently with the socio-cultural conflicts in peri-urban areas, we need a deeper understanding of the relationships between the CES and local social background. In this way, the aim of our study was to increase the understanding on the locals' place attachment and on the relationships between CES and local societies. During our research, we applied a special method (ppGIS) for community-based assessment and involvement of local communities. We took a Hungarian micro-region from Budapest Metropolitan Region as a suitable peri-urban

example. Five cultural services were defined and evaluated: aesthetic, recreational and therapeutic, spiritual, cultural and historic, educational values. During the survey almost 200 maps were collected, after the data was digitized. The analyses were performed partly by GIS methods and partly by statistical analyses. Our results showed, that the regional significance is the highest in the micro-regional centre. The smaller settlements around the regional centre are the least well-known from cultural perception point of view, while the villages located in the middle of the study region are better known. Analysing the place attachment, we could conclude, that citizens of settlements located around the regional centre have the strongest, while villages situated in the middle of the study area have the weakest place attachment. Our results can help for planners and decision makers to understand better the social processes in peri-urban areas, and the relationships between locals and cultural values, heritage of these settlements.

Peri-urban Agroforestry Heritage System. Past, Present and Future of the Mulberry-Dykes and Fishponds GIAHS site of Huzhou City, China

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Peri-urban traditional agroforestry systems are considered a priority at an international level, as they serve as a link connecting cities and rural areas, providing local food and ecosystem services for people living in the cities. The mulberry-dykes and fishponds system (MFS), located near Huzhou city (Zhejiang province, China) developed as a consequence of the ancient flood control system created to protect local cities and villages from recurring floods. This system is recognized for its sustainability and for the strong functional interlinkages between the different components (mulberry trees, fishes, silkworms) by the Food and Agriculture Organization (FAO), which included it into the Globally Important Agricultural Heritage Systems (GIAHS) Programme in 2017. The research intends to measure landscape transformation in the last 12 years and to evaluate the effectiveness of the inclusion into the GIAHS Programme for land use changes mitigation. In addition, an accurate analysis of local planning has been performed to evaluate its capacity in protecting and valorising the site. Results demonstrated that MFS has undergone major land use changes in the last years due to urban sprawl, spread of solar panels (+7% in 2018–2021), and abandonment of the traditional mulberry-based system (−75% in 2009–2021). Other changes are related to the overall number of traditional fishponds (−81% in 2009-2018 and −33% in 2018-2021) and to their shape and size. Local planning tools are too sectorial, not enough integrated one another, and they do not consider the MFS as a single system. The study demonstrated that the inclusion in the GIAHS Programme is not sufficient to stop negative trends in the absence of adequate planning tools, even if it can contribute to slow them down, but it would be crucial to integrate the GIAHS action plan and vision into local planning tools.

The Emergence of Dispersed Rural Urbanization in Sub-Saharan Africa

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Urbanization is rapidly transforming in Sub-Saharan Africa (SSA). While the expansion of cities has been studied extensively, a major similar trend in rural areas has been overlooked. This trend of urbanization is multifaceted and pertains to the use of land, the structure of the economy, and the livelihoods of inhabitants, for example. Rural urbanization is especially pertinent in SSA, as a comparably high share of the population is not living in large cities and where livelihoods are predominantly rural until recently. In this study, we map rural building densification in Kisii County Western Kenya and relate these spatial patterns with drivers and other urbanization processes such as population, economic, social and changes in the connectivity to other places. The results of this study show a large increase in buildings, which locally doubled between 2010 and 2022. Furthermore, the study shows the spatial correlations between newly developed buildings and the other urbanization process, such as change towards urban lifestyles and urban livelihoods. Since this dispersed rural urbanization is associated with land fragmentation, uncontrolled land speculation, high pressure on infrastructure and social amenities, it is important that this form of urbanization will get attention form spatial planners as well as urban planners to manage the negative consequences of this form of urbanization.

The Effects of Climatic, Socioeconomic and Policy Factors on Urban Greening Across China: Evidence From 294 Cities

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Urban greening is of critical importance for ensuring quality of life for urban residents. However, it remains unclear under which enabling conditions urban sprawl and urban densification allow vegetation growth in cities. Urban expansion leads to direct loss of urban green space by converting natural or agricultural land to built-up land. Additionally, urban environments also exert indirect effects on greening through fertilization, urban zonal climate, and horticulture. Yet, it remains unclear how the indirect urban development effects on greenness change and if the indirect greening effects can offset the direct vegetation loss over time. Further, the role of 'top-down' national policy programs on the relationship between direct and indirect greening remains elusive. We used MODIS vegetation index product for quantify greening change, climate data (e.g., temperature, precipitation), and socioeconomic data (e.g., GDP, CO_2 emission, government investment panel data) for drivers examination in 294 cities of China. As an indicator for greening governance, we included the year of implementation of the National Landscape and Garden Cities (NLGC) program which is awarded to cities fulfilling certain green space management criteria. We find the indirect effect of urbanization on urban greening in China was increasing from 2000 to 2018, to

the extent that partially direct losses were offset by indirect greening effects. For the whole of China, the indirect greening effects depended mostly on climatic factors, and we expect socioeconomic and policy determinants on indirect urban greening to increase over time. The NLGC program had a positive influence on indirect urban greening but less pronounced than climatic and socioeconomic effects. Our findings provide further evidence that urbanization can promote vegetation growth through indirect effects. We call for urban greening governance which is adapted to regional climatic and socioeconomic conditions to achieve urban sustainability.

From A Swamp into a City: Population Growth and the Transformation of Bor Town, South Sudan

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Bor town in Jonglei State has experienced rapid population growth in the last two decades (2005- 2023). The growth predicated on an ever increasing rural-urban migration, rapid household growth, an enabling environment and rapid urbanization has resulted in transformation from an otherwise small but historical settlement into rapidly growing urban settlement of more than 300,000 inhabitants. The rapid demographic change within a short period has in many ways affected a sensitive wetland ecology that is dependent on annual flooding cycles. The population growth coupled with unplanned expansion and settlements has in effect resulted into a problematic solid waste disposal, compromised air quality and a low quality of life for the inhabitants, while severely affecting the larger wetland ecology of the region. This paper mainly relies on data from Google Earth images and population censuses and projections for Bor and Jonglei State, which indicates a rapid population growth and settlements. The paper posits that the rapid transformation in Bor town has led to ecological changes on the landscape at the outset of variable environment occasioned by climate change.

Keywords: Bor town, population growth, swamp, ecological changes

Global Urban Water Scarcity and Landscape-Based Solutions

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Abstract: Both the quantity and quality of urban water supplies are increasingly affected by human activities and climate change, challenging the achievement of several sustainable development goals. To understand

the state and trend of global urban water scarcity, we quantified the urban population and large cities (population >1 million) in water-stressed catchments and assessed the water quality risk for large cities based on the human activities in water-source areas for these cities. The landscape-based solutions were also discussed. We found that about 90% of 304 estimated cities faced water risks in 2015. The number of cities facing water quality risk was about three times the number of cities facing water scarcity risk, and nearly a quarter of cities faced dual risks. Lower income countries (e.g., India) had a higher proportion of cities facing water risks. From 2015 to 2050, 18%-41% of cities were projected to face rising water security risks with about one-third of cities facing dual risks by 2050. To address such issues, we need to promote landscape-based solutions to build water-saving, climate-adaptive, and sustainable cities and protect urban water source areas. Specifically, to mitigate such risks, the upper Yellow River basin, most of the Yangtze River basin, the southwest side of the Tibetan Plateau and the upper Nile River basin are source watersheds of greater global importance. In addition, there is an urgent need to promote sustainable urban water planning and governance, improve water supply and drainage infrastructure, and refine ecological compensation regimes to achieve global urban water security.
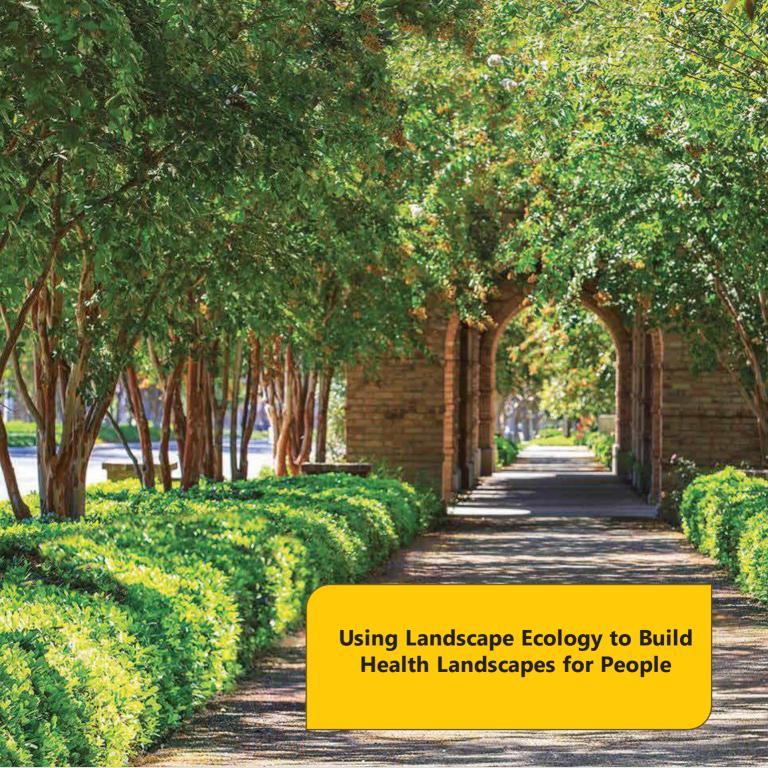
Keywords: landscape sustainability; water scarcity; global change; climate change; urbanization; Sustainable Development Goals

The Role of Emotions in Enabling Urban Transformation Towards Sustainability

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Urban expansion is generating unprecedented homogenization of landscapes across the world. This uniformization of urban forms brings along important environmental, social, and health problems. Reverting such processes requires activating people's sense of place, their feeling of caring for their surroundings, and their community engagement. While emotions are known to have a modulating effect on behavior, their role in urban transformation is unknown. Drawing on large cognitive-psychological experiments in two countries, we demonstrate for the first time that urban homogenization processes lower people's affective bounds to places and ultimately their intentions to engage with their neighborhoods. The dulled emotional responses in peri-urban areas compared to urban and rural areas can be explained by lower social cohesion and place attachment. Furthermore, using structural equation modeling, we show that there is an important mismatch between preferred and actual choice of residential locations: People's emotional signals clearly override their cognitive evaluation of neighborhoods characteristics when selecting their preferred neighborhood, thus choosing locations in which they have low emotional bindings. These findings are not only critical for planning inclusive transformation along the rural-urban grading, but highlight the significance of considering emotions in shaping just, equitable, sustainable, and resilient urbanization.

Using Landscape Ecology to Build Health Landscapes for People

Planning for Sustainable Landscapes in Tropical Areas – How A Landscape Ecology Approach Can Help in The Maintenance of Human Health

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Human population growth puts increasing pressure on societies to convert forested lands to other uses, altering landscape structure and the provision of different ecosystem services to communities, including the maintenance of human health. It is estimated that nearly a quarter of the global burden of diseases can be attributed to environmental and land use changes. Green areas, for example, can reduce pollutant concentrations, affecting respiratory and cardiovascular diseases. Natural areas also affect the transmission risk of zoonotic diseases, those transmitted from animals to humans, with land conversion accounting for 40 percent of all zoonotic outbreaks. Several studies have shown the relationship between the presence of natural areas and different aspects of human health, but few have attempted to include aspects of spatial configuration into account. Since not only the composition, but the configuration of the landscape can be determinants, it is essential to gain a complete understanding of how landscape structure affects human health. Here, based on work with hantavirus, yellow fever, and cardiovascular and respiratory diseases in Brazil, we will show how we can structure landscapes to make them healthier for humans. We will also show what trade-offs and synergies exist in landscape planning when considering different aspects of human health.

How To Estimate Zoonotic Spillover Risk in Tropical Áreas

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Zoonotic diseases, those transmitted from animals to humans, represent 75% of emerging infectious diseases in the world. Therefore, understanding what places people at risk of novel diseases' emergence is key to prevent and control negative impacts, a public health affair and economic priority. Notwithstanding, to date, we lack consensus on zoonotic diseases' definition of spillover risk and how to assess it. Our goal was to synthesize how risk is being evaluated in different studies around the world and build a conceptual framework including how environmental and socioeconomic variables drive the transmission risk of zoonotic diseases, both in rural and urban landscapes of tropical areas. We are assuming that risk is a combination of Hazard, the relative 'amount' of pathogens in stock at a given space and time, representing the potential source of harm; Exposure, the likelihood of human contact with hazards, given each individual perception and activities; and Vulnerability, the likelihood that humans become infected once contact occurs. We carried out a literature review and searches were conducted in English and with no restriction on year. We focused on published studies that measured risk by evaluating one of the three components described above, or the final risk (prevalence of the disease in humans). Our results demonstrated that these studies were widely distributed

throughout the tropics. Our conceptual frameworks show that most of the studies are only evaluating hazard, with large gaps in zoonoses risk assessment and results that may not incorporate all the complexity that these systems have. Integrating hazard, exposure and vulnerability on zoonoses risk assessment would be a step for a better prediction of disease outbreaks in the face of changes in the environment.

Trade-Offs and Synergies in The Planning of Health Landscapes – A Case Study of Four Zoonotic Diseases

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Land use change and deforestation have been linked to the emergence of 30% of infectious diseases worldwide, highlighting the need to understand disease risk from a landscape perspective. Often however, when the impacts of landscape structure are considered on zoonotic disease risk, diseases are often considered in isolation, potentially overlooking synergies and trade-offs in landscape structure among diseases. Further, land use change is generally considered to be instantaneous, with studies evaluating landscape structure rather than transition dynamics. Additionally, many consider land use change in aggregate, without addressing the effects of different land transitions (i.e., conversion from forest to urban areas can have distinct impacts on transmission then from forest to agricultural land).

Our project aims to fill these gaps and understand how landscape structure, in terms of composition, configuration and dynamics, across the region of Minas Gerais, Brazil is affecting the risk of multiple zoonotic diseases. Specifically, Brazilian Spotted fever, Hantavirus, Cutaneous leishmaniasis, and Visceral leishmaniasis, all of which are of public health concern in Minas Gerais. To do so, we leveraged an epizootic dataset from the Brazilian Ministry of Health with case counts for each disease and municipality (n=833), from 2001-2020, in combination with land cover data extracted from MapBiomas using the Google Earth Engine. Preliminary results indicate that most of these diseases have no spatial aggregation, with different municipalities being associated with different diseases. Nevertheless, they seem to respond similarly to certain aspects of landscape composition/configuration. Intermediate amounts of forest cover (20-30%), immersed in a matrix of pasture seem to favor all four zoonoses. For the configuration the edge density also increases the risk of all zoonoses. This suggests more synergies than tradeoffs between these diseases and that a landscape that limits the risk of one zoonosis could also be effective in reducing the risk of other zoonoses.

Rewilding the City: The Exploration of Biophilic Urban Design

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As urbanization has resulted in inevitable contradictions between urban and natural ecosystems, the significant role that the biophilic urban design can play must be urgently figured out to ensure the limited resource is well-utilized and protected in urban sprawl. Its notable potential to become an efficient strategy for urban sustainable development should be widely aware in the field of Landscape Ecology. Since EO Wilson's Biophilia (1984) hypothesis was advanced and incorporated into the concept of Biophilic Design promoted by Kellert (2008), it has been further interpreted and celebrated by scholars around the world, particularly Beatley in Biophilic Cities (2010). However, there has been little attempt to combine biophilia with urban design in China yet.This paper considered the adoption of biophilic urban design in China, analyzed severe urban environmental problems in the past two decades, and proposed compatible biophilic patterns and principles which could benefit the cities in China. Meanwhile, the study explored the relationship between urban ecology, urban species, and urban wilderness through literature analysis and extensive social surveys, and constructed an evaluation index system for urban rewilding. An empirical study was then conducted on several cities in China that are undergoing landscape renewal. Obviously, the results of the simulation test and model experiment claimed as "rewilding the city" show that biophilic urban design would conduce to public health, improve the urban ecosystem, and strengthen the adaptability and flexibility of cities. Based on a synthesis of the relevant theory of biophilic cities, and the key parameters in biophilic design, the paper concludes with strategies for incorporating biophilia in urban design in China.

Examining Human-Microbial Transboundary Ecologies During The COVID-19 Pandemic And The Application Of 'Landscape as Tension' for Interspecies Approaches in The Anthropocene

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There is an absence of social and cultural thinking on the complex transboundary encounters that take place between humans and microbes (virus, bacteria, fungus etc.). On the one hand, non-specialist publics implement practices and behaviours – from hand hygiene to mask-wearing – to mitigate the risks of microbes penetrating the skin. On the other hand, publics express uncertainty about the agency, materiality, and dynamic behaviours of microbial ecologies. Theoretical in scope, this paper aims to fill this gap by working with Wylie's (2007) concept of 'landscape as tension' and Haraway's (2014) writings on interspecies relations. Structured around Wylie's four landscape tensions, I ask, what might infection prevention and protection practices tell us about human's entangled relations with microbes; how are the borders between human-microbe, body-environment, lived and negotiated; when is the flourishing, coexistence, or death of microbial ecologies contested or valued; and what opportunities are there

for kin-making for multispecies ecosystems? To answer these questions, I draw upon interviews and ethnography conducted as part of a UKRI AHRC SARS-CoV-2 funding grant, that examined the structural and personal factors informing the adoption of public health measures onboard public transport during the pandemic. Research findings evidence the role of imaginaries and emotions, rather than medico-scientific knowledges, in driving lay publics decisions to ignore, tolerate, avoid, or kill the potentially present virus. I conclude with an urgent call for greater transboundary thinking in studies of interspecies relations. New ways of articulating and representing human-microbial relations are vital for sense-making of these complex and evolving relations in the Anthropocene: whether from climate change (vectors and modes of infectious diseases spread), migrations (epidemiological range), intensification in farming (microbial resistance), or expanding human-non-human interactions (new zoonotic diseases).

Estimating the Economic Benefits of Green Areas for Human Health

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Economic demands, particularly on lower socio-economic regions, often require large-scale deforestation or vast landscape change to support industries such as commercial agriculture, ranching, logging, small-scale mining, or slash-and-burn farming. The subsequent loss of green areas can contribute declining ecosystem services: carbon sequestration, water and soil quality, and especially human health and wellbeing. Associated with the decrease of these services are economic losses often overlooked by policy makers and other stakeholders when planning landscapes. For human health, economic losses generally relate to the costs of prevention and treatment of chronic diseases and zoonotic diseases. We developed science-based evidence to support policies protecting and advocating for preserved green areas in two different regions of the world and showed that: (1) the protection of indigenous territories in the Brazilian Amazon could avoid 15 million cases of respiratory and cardiovascular diseases and save 2 billion dollars in health costs per year. In addition, we estimated an economic health cost of $2,112,595 USD for every hectare of Amazon burned. (2) a cost-benefit analysis on the creation of proposed protected areas in Liberia showed that benefits are about 300 times greater than the costs, with values that could reach 21 billion USD in a ten-year period. Benefits included ecosystem services, sustainable agriculture and industries, eco-tourism, and promoted human health, while costs were lost income from artisanal mining, logging, and operation costs for protected area management. These examples show two different techniques for valuing ecosystem services associated with human health that have great potential to be used for decision making and could show the large importance of these areas to human well-being.

PANEL SESSIONS

1. HOW TO UNLOCK THE TRANSFORMATIVE POTENTIAL OF MULTILEVEL AND INTEGRATIVE LANDSCAPE APPROACHES?

Panelists

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Fostering Transformative Change for Enhancing Biodiversity (Introductory Talk)

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As defined by IPBES GA, 2019, transformative change requires a multilevel and cross-sectoral approach to achieve a "reorganization across technological, economic and social factors, including paradigm, goals and values". To better understand how we can foster transformative change at the landscape level, considering the influence of policies from multiple levels and sectors, we used an adapted version of the conceptual framework suggested by Wittmer et al.

2021. With this context, we will introduce the BioValue Horizon Europe project. In support of the EU Biodiversity Strategy 2030, the project aims to identify and upscale opportunities for valuing biodiversity in the multi-level governance context of the EU. BioValue aims to leverage transformative change by better articulating three instrumental perspectives relevant to spatial policy and planning: (i) spatial planning and management instruments, (ii) environmental assessment instruments and (iii) economic and financial instruments to enhance biodiversity by analyzing the potential of the instruments and their interactions in local case studies.

Unveiling the Transformative potential of European Spatial Planning Systems for Biodiversity and Ecosystem Services

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Implementing transformative changes that trigger foundational and systemic reforms is an emerging topic in the policy debate for reversing biodiversity degradation. This study identifies key components of different spatial planning systems and assesses them against the concept of transformative change toward ensuring biodiversity protection and ecosystem services enhancement. We developed a framework based on the scientific literature to envision important characteristics

of transformative changes for spatial planning, including restructuring (i.e., substantial variations of the system's components and their interactions), path-shifting (i.e., redirection of current trends and principles governing the system), innovative (i.e., changes not implemented before driven by new knowledge) and multiscale (i.e., changes covering several spatial, temporal, and governance scales and sector and mutual synergies). The framework describes these four characteristics for several elements of analysis within spatial planning systems, which were selected based on their relevance of transformation "for", "beyond", and "of" biodiversity. Specifically, we focused on the governance of spatial planning systems to understand changes in how the systems organize to take and implement planning decisions and the mitigation hierarchy which supports this planning process for avoiding, minimizing, restoring, and offsetting impacts on biodiversity. Another element was the spatial planning provisions of different sectors, including transportation, agrifood, and energy, because of their indirect impacts on nature. Biodiversity and ecosystem services were the last element of analysis to assess changes in the structure and functioning of ecosystems (e.g., size, diversity, ecosystem conditions, and ES supply) driven by planning decisions. The framework was applied to eight countries representative of different spatial planning systems in Europe. For each country, we conducted a content analysis of selected spatial plans across all governance levels. Current practices of restructuring, path-shifting, innovation, and multiscale are presented and discussed, such as the simplification of regulatory instruments, legislative changes to support a broad stakeholder involvement, mapping ecosystem services, and using nature-based

solutions and prioritization methods, among others. Finally, through a cross-system comparison of results, insights are provided on the transformative potential of different spatial planning systems, and light will be shed on the practices/arrangements/instruments to phase out for being outdated or harmful. These results can contribute to operationalizing the concept of transformative change in spatial planning for meeting the EU Biodiversity Strategy 2030 targets.

Exploring "Willingness to Care" for Transformative Change: Methodological Approach Through the Lens of Cultural Ecosystem Services

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The concept of "Willingness to Care" (WTC) will be explored as an entry point for the identification of biodiversity stewardship a context of Transformative Change. The concept of stewardship has focus on the experiences in which the administration of natural resources is carried out in bottom-up processes. More specifically, biodiversity stewardship has been related to conservation aims by encouraging landowners safeguard of biodiversity in their lands. In this approach the WTC will be approached from the current relation that citizens have to ecosystem services. This communication explores novel approach of the concept

of biodiversity by relating it with the Cultural Ecosystem Services (CES). In the case study of Mafra municipality (Portugal) a Participatory Geographic Information Systems (PGIS) provides information on the most valued natural areas and investigates the "willingness to care" of those spaces by citizens. The discussion will assess the benefits and limitations of the methodology for linking CES and the biodiversity stewardship. Finally, the results will be analyzed in the framework of Transformative Change provided by Wittmer and colleagues (2021). The research is carried out in the context BioValue project (biovalue-horizon.eu).

Understanding Cultural Landscapes in the Pearl River Delta: Using Multi-scaled Identification of Landscape Character as a Tool

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Urban deltas have become densely inhabited through the creation of urban centers and harbors throughout history and are now among the most promising regions in the world. However, being the most densely populated part of the world and hardly above sea level, urban deltas are extremely vulnerable to environmental threats with a loss of ecological and social-cultural values. As an extreme case, the Pearl River Delta (PRD) has been the fastest-developing delta in the world for more than 40 years. The interaction of the delta's specific climate and complex water systems with human activities led to the development of a variety of ecologically adaptive cultural landscapes which are experiencing the loss of diversity, sociocultural fragmentation, and loss of spatial identity as well as accelerated processes of physical landscape fragmentation due to environmental threats and the problem brought by administrative boundary controls of the existing planning system. The cultural landscapes are not only worthy of preservation but could also become a basis for sustainable and climate-resilient future development. To guarantee a more sustainable future for the PRD, new types of landscape management processes are necessary that can not only cope with the vulnerabilities but also in enhancing their ability to confront both natural and human-made threats. Therefore, this article uses the framework of Landscape Character Assessment (LCA) to classify landscape characters in the PRD in multiple scales and understand their explanatory factors and relation with the hydraulic society, to propose protection plans and measures for the existing cultural landscapes to stimulate their potential use in future-oriented spatial development.

Gaps in Teaching Ecological Restoration in Secondary Education Across Europe and the Way Ahead

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The recent draft of the European Restoration Law shows the transnational relevance of ecological restoration manifested in governance. To restore landscapes in practice, education is needed on multiple levels, often also at the non-academic levels of the European Qualification Framework (i.e., in vocational education and training (VET)) to ensure implementation. However, recent studies have identified a weak diffusion of ecological restoration in VET. In TEAM#UP, we aim to mobilize extensive knowledge and skills from the third cycle in the field of ecological restoration to fill gaps in green VET. Thematically, TEAM#UP will address the following arenas across Europe: (1) multifunctional and sustainable land use in agricultural systems, (2) restoration of old infrastructure, ecological compensation and landscaping, (3) restoration across urban and rural landscapes, (4) forest restoration and disaster risk management. TEAM#UP will test different approaches to extend the realm of education on ecological restoration to secondary education. We will extend the use and creation of demonstration sites for ecological restoration both into secondary education and outside the ecological arena (e.g., agriculture, forestry). Methodological, we will explore options to train teachers to teach students to visualize demonstration sites with augmented/virtual reality approaches or to develop open education resources.

2. TRANSLATING THE POST-2020 GLOBAL BIODIVERSITY FRAMEWORK (GBF) INTO LOCAL PRACTICES: TOWARDS TRANSFORMATIVE BIODIVERSITY CONSERVATION GOVERNANCE IN AFRICA

3. RESILIENCE AND SECURITY OF BIOCULTURAL LANDSCAPES OF ARID REGIONS

Panelists

Antonio Santoro[1] and Gloria Pungetti[2]

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Traditional Oases in Northern Africa as Multifunctional Agroforestry Systems: Ecosystem Services and Main Vulnerabilities

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Traditional oases represent unique forms of adaptation to extreme environmental conditions, developed through the centuries by local farmers to support their livelihood, combining different crops (date palms, fruit trees, vegetables and fodder) with livestock breeding. The aim of the paper is to investigate the variety of Ecosystem Services (ES) and the main vulnerabilities related to traditional oases in Northern Africa countries

(Morocco, Algeria, Tunisia, Libya, Egypt) through a systematic literature review, a methodology commonly used to assess the state of art of a certain topic and to identify perspectives. The search returned 909 potentially interesting papers published from 2005 to March 2022, reduced to 257 relevant papers after a double-step filtering phase. Provisioning Services, in particular "Genetic diversity, agrobiodiversity and biodiversity", are the most cited ES (in 36% of the papers) followed by Cultural Services, mainly represented by "Traditional knowledge systems, cultural heritage and sense of place" (17%). The main vulnerabilities are water-related issues (desertification, drought, salinization, overexploitation), followed by decrease of agrobiodiversity due to the spread of monocultures of commercial date varieties, and by social transformations (depopulation, loss of traditional knowledge). The study demonstrates that traditional oases still provide multiple ES to local communities, actively contributing to their wellbeing and livelihood. These systems are located in arid environments, where agricultural activities have to be based on traditional knowledge. Different attempts to modernize agriculture and to increase yields have been made, but almost everywhere leading to water salinization and overexploitation. The study also underlined that despite the social, economic and cultural importance, these agroforestry systems are facing multiple socio-environmental threats. The future of traditional oases in Northern Africa is related to the development and replication of virtuous examples and innovative solutions, including: involvement of local farmers in touristic activities, quality labelling for local products valorization, use of palm byproducts.

Biocultural Landscapes of Arid Regions as Provision of Ecosystem and Cultural Services

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Biocultural landscapes of arid regions are fragile ecosystems where the interaction between people and nature is one driver of changes. The understanding of this interaction is crucial for their survival, and traditional ecological knowledge is a way forward. These landscapes are provision of ecosystem services, with their natural heritage, microclimate, biodiversity and fresh water, as well as of cultural services, with cultural heritage, traditional agriculture, agrobiodiversity, irrigation systems and local knowledge. However, these services are under threat for the decrease of their provisions, due to changes in climate, local activities and socio-cultural structure. Oasis landscapes are a particular type of biocultural landscapes of arid regions, very vulnerable and strongly dependent on water provision, sustainable practices and participatory management. Livelihood, water and food security are key aspects of these landscapes. The paper contributes to the discussion on landscapes of arid regions through the dichotomy between historical and traditional vs modern oases, natural vs cultural landscapes, agrobiodiversity vs monoculture, traditional irrigation vs desertification, globalization vs local knowledge. It also supports debate on how arid biocultural landscapes could be socio-ecological systems that can contribute

to environmental conservation, resilience and human wellbeing.

4. WHAT GENDER TRANSFORMATIVE ADAPTATION STRATEGIES CAN BUILD CLIMATE RESILIENT LIVELIHOODS IN SUB-SAHARAN AFRICA?

Panelists

Dicta Ogisi[1], Katharine Vincent[2], Nafisatu Mohammed[3], Chris Shisanya[4], Dan Olago[5], Okumba Miruka[6], Olgah Malapane[7], Lingyun Liao[8], Ursula Hillary Tumamo Djuidja[9] and Rejoice Nyoni[10]

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Transmission of Indigenous Knowledge Systems Under Changing Landscapes within the Vhavenda Community, South Africa

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Indigenous Knowledge (IK) and techniques do not only benefit humankind, but they also benefit the environment. Nevertheless, the transmissions of IK are threatened and replaced by Western Knowledge and ideologies. Thus, this article aims to demonstrate the various IK transmission methods of the Vhavenda people, their importance in their daily lives, and how preserving this knowledge has enabled them to survive in changing environments. The focus of the study was to demonstrate the various IK transmission methods, the driving forces behind their disappearance, and how they added value to the resilience of such knowledge forms in sustaining indigenous and local communities throughout the centuries. To achieve this, the study used questionnaires consisting of open-ended and closed-ended questions (n = 136). Data were collected only from principal elderly participants who were above 40 years because of their profound knowledge and experiences with their local environment. Participants were selected and identified through purposeful sampling from five remote indigenous villages of the Vhembe District within the Limpopo Province in South Africa. The most prevalent IK within the Vhavenda people is folklore which is transmitted orally from one generation to the next through traditional songs, stories, dance, myths, customs, and rituals. The results revealed that even though IK is still prevalent and essential to the Vhavenda tribe, the transmission of such knowledge has been hampered by several factors, including the invasion of technology, modernization, religion, and the reluctance of elders to pass down wisdom to the younger generation. Participants indicated that folklore and informal education are the

frequently used mode of IK transmission. The study recommends revitalizing this knowledge system through documentation and integration into the mainstream education system and calls for integrating IK and scientific knowledge.

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Due to the frequency of natural disasters, attention is being paid to the capacity of communities to respond to all types of crises. China is one of the most natural disaster-prone countries in the world, and its national parks are often at greater risk, with national park communities becoming the main risk-bearers. There is therefore an urgent need to conduct resilience assessments of national park communities so that they can be spatially regulated. In this study, the only three remaining communities within the Wuyishan National Park and nine gateway communities were selected as research objects, and indicators were chosen from ecological, economic and social dimensions to construct a resilience assessment index system for rural communities based on the national park policy context. The study shows that: (1) The communities within the park have an average level of resilience and show low resilience in the ecological and social dimensions due to frequent natural disasters and national park policy controls; economically they show high resilience due to the well-developed tea industry, but there is a trend of weakening economic resilience due to the single industrial structure. (2) Surrounding communities show high ecological resilience due to natural conditions similar to those of the national park and fewer natural disasters; economically and socially they depend on the policy and resource context of each area, and there are significant differences between areas. (3) Controlled development of communities within the National Park according to their level of resilience, maintaining the status quo while clustering villages to prevent their expansion into the core area, and moderate tourism development to enhance industrial diversification. Surrounding communities will be developed in clusters, gathering in communities with better resources and industrial status, and driving synergistic development in the surrounding communities.

Applying Intersectional Perspective to Analyze Climate Change Adaptation Strategies of Rural People in Dryland Cameroon

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Climate change has negative impacts on agro-sylvo-pastoral activities which represent the main livelihoods of the rural population in the Dryland Cameroon. These impacts are experienced differently among distinct social groups (men, women, migrant and non-migrant, Christian, Muslim, etc...) present in the area. By applying an intersectional lens, this paper identifies the adaptation strategies of farmers and pastoralists in the

Dryland Cameroon and analyses how the interaction between sociocultural norms/rules and identities shapes these adaptation strategies. The study is drawn on 61 in-depth interviews conducted with farmers and pastoralists in 5 villages in the North Region of Cameroon. The main results show that farmers and pastoralists of the North Region use both coping/short-term strategies (lower production cost, sale of livestock to solve an immediate problem, traditional astrology to get meteorological information, etc...) and long-term strategies (use of improved varieties, agroforestry techniques such as planting cashew nut and neem in the farm, as well as agroecological techniques such as the construction of dikes, stone barriers to prevent flooding and erosion, etc..).While long-term adaptation strategies are more used by men and non-migrants, women and migrants rely more on short-term adaptation strategies. Indeed, the access to the resources (land, credit, information, etc...) they need to put in place sustainable and off-farm measures (such as migration to seek employment), are highly constrained by sociocultural norms/local rules related to their gender, marital status, religion, and residential status that define their roles and responsibilities in their households and their communities. The paper recommends that climate change adaptation interventions, aimed at strengthening the adaptation capacity of the rural population in the North Region of Cameroon, should highlight the intra-gender and intra-residential status differences that shape adaptation options.

Understanding the Dynamics of Climate Information for Smallholder Farmers: A case Study in Sub-Humid Region of Zimbabwe

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Climate variability poses a high productivity risk especially in rainfed agriculture. Climate information (CI) services have been increasingly promoted as a key adaptation strategy to climate variability. The aim of this study was to understand how smallholder farmers access and use CI to make decisions at each stage of crop management. Most studies on CI services are conducted in arid and semi-arid regions creating a gap on the benefits of CI services in humid and semi humid regions. A total of 30 smallholder farmers in three villages of Murehwa District (high rainfall region in Zimbabwe) were monitored fortnightly from the start of the cropping season to the end. The assessment considered demographic information, access to CI, dissemination channels, use and whether the CI was provided by technical institutions or based on indigenous knowledge (i.e. indicators based on ecosystem observation). A Multiple Correspondence Analysis in R was conducted to assess the relationships of the variables. Results indicated that the smallholder farmers particularly paid attention to the seasonal forecasts and onset or start of rainfall, accessed through the radio, agriculture extension officers or indigenous knowledge. As the season progresses the smallholder farmers use less CI and rely on observation of clouds and their surroundings for daily management. Access to

CI is linked to an increase in education levels, group affiliations, access to extension services and livestock diversification. However, it was noted that despite having access to CI the farmers' decisions were greatly influenced by the availability of financial capital, seed and labour. The farmers were able to effectively make use of scientific forecast and indigenous knowledge without contradictions. The results highlighted the importance of disseminating tailored CI for agriculture. Participatory approaches may present a great opportunity for designing CI services that consider all the farmers' decision factors.

5. TOWARD EQUITABLE PUBLISHING IN LANDSCAPE ECOLOGY: IDENTIFYING BARRIERS AND SOLUTIONS

Panelists

Sima Fakheran[1,2], Anita Morzillo[3], Jingle Wu[4], Henry Bulley[5], TakeeshaMoerland-Torpey[6] and Luca Luiselli[7]

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6. LANDSCAPE APPROACH TO WILDLIFE MANAGEMENT IN INDIA: A REVIEW AND WHERE DO WE GO FROM HERE?

Panelists

Ramesh Krishnamurthy[1], Karunakaran P.V.[2], Debajit Datta[3], Bindu Raghavan[4], Parabita Basu[5], Amrita Neelakantan[6] and Samuel Cushman[7]

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1. GREEN INFRASTRUCTURE AS SOCIO-ECOLOGICAL SYSTEM: PLANNING ACROSS BORDERS

Contribution of Green Infrastructure to the Territorial Network of Ecological Stability (Example from Slovakia)

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The territorial network of ecological stability is created by elements of green infrastructure in open landscape. The network of biocoridoridors, biocenters and interactive elements increase connectivity of high diversity landscape features (HDLF) especially in intensively managed agricultural landscapes. They are often small fragments of natural or semi-natural vegetation and specific habitats in agricultural land which, compared to their relatively small size, provide important contributions to ecosystem services and biodiversity. The methodological approach for assessment of green infrastructure elements develops biophysical methods by using qualitative indicators and field data, including land use and habitat composition, conservation status of habitats, naturalness of habitats, ecosozological characteristic of habitats, index of stability of land use elements. The assessment was applied on a local level – on the example of the Dolný Lopašov study area. The result shows the positive impact of green infrastructure in most threatened landscapes around barriers and conflict areas, e.g. mining area, landfills and roads. The habitats increase protective, aesthetic, inhibitory, filtering and hygienic functions and contribute to the reduction and filtration of dust; noise, and contributes to the regulation of waste, toxic substances and other pollutants. The alley of fruit trees and fluvial forest in open landscape with the dominance of large-scale arable land creates important refuges especially for birds and contribute to the diversification of the landscape. The natural and semi-natural habitats, characterized by favorable conservation status form the framework of the territorial network of ecological stability and contribute to the regulation of local climatic conditions and air quality.

A Rapid Assessment of Urban Tropical Landscapes using i-Tree Canopy: A Study of Metro Manila

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Rapid assessment and ecosystem valuation of urban landscapes involves a quick and systematic evaluation of the ecological health and quality of an urban environment. This type of assessment is often used by urban planners, landscape architects, and environmental scientists to quickly evaluate the environmental condition of urban areas and identify areas that may require further study or remediation. This assessment can help to inform policymaking and resource allocation decisions by quantifying the benefits of different ecosystems and comparing them to the costs of different management or development options. Decision-makers can make more informed choices that consider the long-term economic, social, and environmental consequences. This study used i-Tree Canopy to estimate the ecosystem services such as air pollution removal, carbon sequestration, energy savings, stormwater interception, and many others provided by urban trees in Metro Manila, Philippines. Five hundred samples were randomly generated by i-Tree derived from the seven land cover classes within the study area. The overall annual estimated value of Metro Manila's ecosystem services was US$27,374,212. Carbon sequestration was estimated at 40.04 kilotons with an estimated value of $7,732,574. Total pollutants filtered was estimated at 886 tons and valued at $11,732,183 while 3,262.06 kiloliters of avoided runoff was valued at $7,909,455. Additionally, 647.86 kilotons of carbon stored in trees was estimated with a value of $7,909,455.03. Overall, the ecological benefit from urban green spaces of Metro Manila was valued at $152,475,994. With the current density of Metro Manila already at 21,765 per square kilometer and a 14.5 million population by 2025, there is a need to increase the urban green footprint within the city to ensure a more inclusive and sustainable future. This can be achieved by utilizing public road rights of way as planting strips, brownfields as urban forest and creation of urban wetlands.

The Potential of Green Infrastructure for Sustainable Transitions in Metropolitan Fringes: Advances and Challenges in São Paulo Metropolitan Area

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The metropolitan fringes are composed of municipalities and districts in a transition area with urban, environmental, and rural characteristics. These complex territories have been approached as stigmatized spaces and in the scope of urban planning this view is reinforced due to the disintegration between environmental and urban policies to the detriment of its strategic character. In São Paulo Metropolitan Region (RMSP) - Brazil, the fringe areas concentrate natural

remnants that constitute an important part of the metropolitan green infrastructure. In general, the fringe areas of RMSP are occupied by peripheral districts of the main municipality (São Paulo) and by medium and small-sized municipalities that manifest geometric rates of urban population growth higher than those of the Capital, especially in the northern sub-region. This growth rate has been associated with environmental degradation and a sprawling urbanization model. By understanding metropolitan resilience through the lens of landscape ecology, this work aims to discuss models for the sustainable development of the fringes and the role of green infrastructure present in this territory as triggers for sustainable transitions towards resilience. To this end, the work approaches a multi-scale perspective and presents an overview of regional policies for urban resilience that affect the territory of RMSP, maps the main potentialities and deficiencies of the northern sub-region of RMSP and reflects on a set of recommendations for metropolitan fringe areas that aim to conciliate climate change adaptation, ecosystem services and territorial dynamics through a multi-scale approach.

How the Post-War Green Belt Plannings and Multi-Nuclear Network Structure Have Affected the Population Dynamics and Spatial Distribution of Green Space? — A study in Tokyo Metropolitan Area, One of the Asian Megacities

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The "Garden City" theory proposed by Ebenezer Howard has deeply influenced metropolitan regions all over the world, through evolving into a kind of regional urban planning that connects green belt with satellite cities. Meanwhile, in Asian megacities, the satellite cities planned in this way have been transformed into sub-urban centers as the city further expand. Gradually, new satellite cities have been created on outer edges. As a result, a multi-layered, multi-nuclear network structure is forming in Asian megacities. On the other hand, the regional urban planning of 21st century is at a major turning point from population-urban expansion to population decline and urban contraction. This study focuses on the Tokyo metropolitan area, one of the Asian megacities, to clarify how the post-war Green Belt plannings and multi-nuclear network structure have affected the population dynamics and spatial distribution of green space. After sorting out the government policies and plannings, the satellite cities of Tokyo metropolitan area were classified into 4 types from inside to outside: business, public transportation, suburban center and surrounding cities, which respectively correspond to four time periods: 1985-1994, 1994-2004, 2004-2013, 2013-2022 year. In addition, relevant indices are set to clarify the green space change in area and distributed direction. And a normalized index (NDI) is applied in 500m×500m precision grid to compare the changing situations between green space and population density. At present, the result indicates green space in Tokyo

metropolitan area keeps shrinking, and the shrinking direction is opposite to the bearing of satellite cities. Moreover, those areas with significant changes of green space and population are concentrated beyond 20 kilometers from the city center. Next, the future scenarios models of dynamic changes of population density and green space will be constructed to help government formulate policies.

Green Infrastructures to Increase Societal Resilience: The case of Biological Hazards

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Green infrastructure planning has mostly gained attention on the policy and science agendas as a crucial planning strategy to face climate change. However, their impacts cross the border of single risk mitigation. Green infrastructure functions are not limited to single climate regulation and their values for society are multifaceted. The covid-19 pandemic reminds us that other natural hazards are also jeopardizing our life balance deeply influencing our recreational habits. How can urban green infrastructure availability leverage societal transformation for a higher resilience in the face of biological natural hazards? In this study, we investigated, which roles the urban rivers played during the darkest period of the covid-19 pandemic, namely when all indoor recreational activities were suddenly closed, offering recreational opportunities. The objective of the study is to leverage new insights about the multiple potentials of green infrastructures for societal transformation. We applied a two entries methodology with a user survey and mapping. The study was performed on two German cities, Munich and Augsburg, because both case study sites offered a similar temporal and regulatory framework. Within both cities, short-term regulations reduced indoor recreational offers and reduced mobility capacity. The results showed that: 1. Urban green spaces contributed to providing "recreational refuge" in the pandemic crisis; 2. river corridors enabled the short-term transformation of recreational behaviors; of users in face of biological natural hazards; and 3. near-natural urban rivers offered recreational opportunities that replaced, at least partly, recreational activities "into the wild" and supported a transition to lower transportation needs. To conclude, we discussed the recognition of urban green spaces as crucial infrastructures to support societal resilience in face of biological natural hazards.

Development of Green Infrastructure Across Disciplines - Insights of Stakeholder Analysis and Governance Approaches in the Alpine Region

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This presentation focus on a stakeholder analysis conducted as part of the Interreg Project LUIGI – Linking Urban and Inner-Alpine Green Infrastructure-Multifunctional ecosystem services for more liveable territories (2019-2022). The project addressed the development of a transalpine GI-network with multiple ecological, economic and cultural benefits linking rural and urban areas, while looking at representative food-tree-based land use systems (such as orchards) and other semi natural farming systems, their value-chains for goods and services, related business models, financial and policy instruments. As part of the project participatory and governance approaches of good practice examples have been investigated. For this, an in-depth analysis was conducted comprising 11 case study regions in six different countries. In each case study area representatives of six different stakeholder groups have been interviewed, leading to 69 interviews in total. Finally, more than 1000 transcript pages have extracted from these interviews building the data set for analyses. This talk will present and discuss the outcomes.

Metropolitan Green Infrastructure Based on a Co-Construction Process: The Lisbon Living Lab Experience

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Research programs and projects have become increasingly focused on producing socially relevant research. To that end it is acknowledged that researchers need to step out of the academic context, find ways to tap into other bodies of knowledge, as those provided by non-academics, stakeholders, and practitioners. Here, we describe the rationale and the method used in establishing a Green Infrastructure (GI) network based on a co-construction process engaging multiple stakeholders in the mapping and assessment of ecosystem services (ESS). A Working Group on "Metropolitan Green Infrastructures" within a Living Lab setting gathered multiple actors joined by the common purpose of overcoming the absence of a coherent green infrastructure for the Metropolitan Area of Lisbon as a way to maintain the benefits and services that ecosystems provide. The collaborative process was undertaken in the Lisbon Metropolitan Living Lab, in the context of the ROBUST project (urban-rural.eu). It showcases the process of developing a metropolitan GI network using a bottom-up approach within a transdisciplinary research context, notably to identify the phases, assess catalysts and constrains within the process and a putting forward a model enabling its application elsewhere.

Characterizing Spatiotemporal Patterns of Green Infrastructure with a Multiscale Landscape Approach a Case Study of Delhi, India

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Understanding Social-Ecological Sustainability of Urban Landscape, from a Prospective of Urban Parks' Health Benefits in Beijing, China

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The rapid urbanization with consequent land-use change and ecosystem degradation have caused various environmental problems, and lead to the progressive separation of urban residents from nature. Faced with enormous challenges on public health, urban green space planning interventions have emerged as an important issue and nature-based solution for sustainable development of cities, especially in high-density urban areas. However, few studies have focused on the role of urban parks in affecting health outcomes and the differences among population groups. Considering the area proportion of total green spaces and urban parks within different spatial scales, and different urban park distribution characteristics including availability, accessibility, and attractiveness, this study attempted to understand the associations between urban parks and self-reported health of urban residents, and to identify the variation among population groups. Based on a series of spatial explicit assessment and multi-regression analyses, results showed that the area proportion of urban park was more significant than that of total green spaces in affecting health outcomes, no matter in neighborhood or sub-district scales. Among various dimensions of urban park distribution characteristics, accessibility was found to have more significant impacts on health outcomes than availability and attractiveness of urban parks, especially for the elderly group. To create healthy and equitable settlements, these findings suggested that planners and managers should give urban parks extra priority in green space decision-making, and provide more conveniences for the vulnerable groups to access parks. Further research into exploring the assessment of different planning-related urban park distribution characteristics, and associations between different urban park types and health outcome could provide more exact and practical information for planners and managers.

2. PRODUCTIVE URBAN AND PERI-URBAN LANDSCAPES – BENEFITS, CO-BENEFITS AND NEW MODES OF PLANNING

Existing Knowledge, Research Gaps, and Future Ecosystem Service Demand from Urban Street Trees, in East Africa.

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Urban street trees (UST) provide multiple ecosystem services (ESs) against multi-scaled problems facing urban areas associated with climate change, pollution, and mental health. Selecting the right UST species providing needed ESs, while matching urban plantation site requirements maximize ESs delivery that improves urban-life quality. Despite political and scientific recognition of the need for urban greening, urban resilience, and climate change fighting, the growth behavior of USTs, ESs prioritization from UST, and community preferences for UST species remain unstudied, particularly in the East-African context. Our meta-analysis of publications from East African countries showed; 55 papers about urban green infrastructure, 44 papers about urban ecosystem services, 35 papers about urban forestry, and, 8 papers about urban trees, and no papers about UST species selection were found, using SCOPUS, WoS, and PubMed databases. In this presentation, we will present an approach for how to identify suitable native tree species that would deliver needed ES for two cities in Ethiopia, Addis Ababa, and Hawassa. Through a multi-stakeholder workshop held in November 2022, prioritization of ES from UST, UST species recommendations, and UST challenges were identified for different Ethiopian cities including Addis Ababa and Hawassa. We also invited senior researchers to suggest suitable native UST via electronic email. The workshop results showed; i) the needed ESs from UST vary between cities, ii) ornamental value, ever-greenness, tree size, and year-round cooling capacity were used as UST selection criteria, iii) existing challenges of UST were identified. To increase our knowledge of the species identified at the workshop and from the senior researchers' recommendations; measuring functional traits (indicating species resistance to environmental stress), then laboratory-based measurement of drought and waterlogging threshold for selected species will be done. Finally, species distribution models for selected species under climate change and test-based measurements will be conducted for the best species only.

Ecosystem Services in the Milan South-Eastern Edges. An Analytical Proposal for Interdisciplinary Research

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Among peri-urban rural systems, human and ecological dynamics are tightly interweaved and need to be coupled when peri-urban land functional rehabilitation is addressed. In the light of such a premise, the here presented study intends to give a contribution on the understanding and accounting of the ecological and cultural functions and services that can be delivered by peri-urban agroecological participative approaches interlinked with agroforestry and landscape features multifunctional management practices. With this aim, landscape ecology and geographical studies are being led among the Milan south-eastern rural edges, in an

area interested by different agroecological projects and multistakeholder strategic visions. On the ecological side, the study was focused on a multi-scale analysis of the structural and functional traits of the landscape mosaic. Patches size, shape, diversity and connectivity indexes have been compared: i. framing the local scale peri-urban landscape system vulnerabilities and resilience traits; ii. featuring the pilot area context by comparing its current state to a project scenario where agroforestry multifunctional landscape features are further implemented, mitigating the landscape texture gaps. Some functional indicators have been mutuated from the landscape bionomics approach. These results have been integrated into a wider trans-disciplinary methodological framework that was set up with the aim of assessing the current and potential capacity of the area of implementing and generating both Ecosystem Services and Cultural Ecosystem Services. Indeed, a specific study is being led on the identification and evaluation of cultural and social spillovers generated within the regenerative agriculture and agroecology projects implemented in the area starting from 2019, through different qualitative research methods such as surveys, semi-structured interviews and community mapping. The evaluations emerged from the study already highlight multi-faceted positive contributions of the practices under study, and represent useful methodological premises for the further integration and implementation of the transdisciplinary assessment methodology, targeted for peri-urban systems peculiarities.

Tomatoes from the Waste-Water Treatment Plant - Scenarios for An Urban, Resource-Saving Agricultural System of the Future

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In times of increasing urbanization, growing sustainability awareness and increasing resource scarcity, feeding the world's growing population faces various challenges. In addition to climate change, the unavailability and limitations of fertilizer inputs are expected to have an impact on current and future agricultural production systems. The potential of resource recovery from wastewater for agricultural production and for linking wastewater systems to food production has not been sufficiently explored so far. Our aim is to investigate this innovative form of food production that can be integrated into urban structures to shorten supply routes and make food security more self-sufficient and sustainable. To this end, we are addressing the question of how agricultural systems can be designed to be climate-sensitive and resource-efficient, and at the same time be efficiently integrated into urban spaces. Together with stakeholders from science and practice, a multi-stage scenario study was conducted in 2021 to identify different influencing factors for future pathways of a resource-saving and urban agricultural system. Scenario stories were then formulated based on three selected key factors for different locations in the Ruhr area in Germany. As a result of the process five scenarios present opportunities and needs for action as well as potential risks and challenges for combining urban agriculture with wastewater treatment plants. The scenarios show

the interaction between urban development and the new ways of linking wastewater systems and agricultural systems (NEWtrient® centers) up to the year 2050. Moreover, they describe the role that residents will play in future agricultural production and nutrient recovery. In addition, the scenarios show what the wastewater treatment plant of the future could look like as a sustainable, resource-conserving agricultural production system.

Achieving Collective Action of Climate Mitigation Practices Adoption in Rice Social-Ecological Systems in Japan

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Rice paddies are responsible for approximately 9.9% of the greenhouse gas (GHG) emissions from the agriculture sector, ranking first in greenhouse gas intensity among the main food crops. Extending midseason drainage is a major climate mitigation practice for rice farming that is encouraged by the Japanese government by incorporating it in the menu of direct payments for environmentally friendly agriculture. However, consumer survey shows that Japanese consumers are less willing to pay more for rice that decreases GHG emission than rice caring for other environmental problem like biodiversity loss. Lack of economic benefit may reduce rice farmers' incentives for the adoption of climate mitigation practices. Extending midseason drainage is a water management practice that requires the collaboration of rice farmers, therefore, achieving collective action is an important issue in promoting this climate mitigation practice. We took a value chain approach and conducted interviews by the method of snowball sampling with stakeholders including officers, Japan Agricultural Cooperatives (JA) leaders, rice farmers, researchers, etc., that contributed to the massive adoption of extending midseason drainage in rice paddies in several prefectures in Japan to identify factors of achieving collective action of climate mitigation practices in rice farmers. By constructing the collaborative network of these regions, our research emphasizes the importance of collaborative management by identifying the role each stakeholder plays in achieving collective action, especially the role of JA. Our research points out the conflict between climate mitigation practices and biodiversity conservation practices in rice farming. Our research also suggests that rice farmers have more incentives to adopt extending midseason drainage when they realize it is also good for rice growth, therefore we suggest that the benefits for rice growth should be included when promoting climate mitigation practices in rice farmers, and future research is required to provide other incentives for farmers.

Public Versus Private: Juxtaposing Urban Allotment Gardens as Multifunctional Nature-Based Solutions. Insights from Seville

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Many European countries witness growing interest in allotment gardening. Thus, private allotment gardens (AGs) have been created in some countries, including Spain. As a result, there are places where non-consumptive and commodified allotment gardens coexist. The paper presents an in-depth comparison of public and private AGs through the lens of the nature-based solutions (NBS) concept. First, we assess the importance that gardeners attribute to the spectrum of environmental and socio-economic impacts provided by both types of AGs; we identify differences and similarities in their development and management, and assess the demographic and socioeconomic profile of gardeners. Subsequently, we discuss gardeners' and other stakeholders' opinions on both types of AGs and explore the roles that they can play as solutions for urban policy challenges. Our results show that both types of AGs are nature-based solutions with particularly positive impacts on the health and well-being of their users. These gardens do not compete but complement each other, fostered by their role as multifunctional nature-based solutions. Moreover, the option of cultivating a private or a public AG seems to be more linked to the freedom of cultivation and the freedom of access rather than economic reasons. We conclude that in the current complex scenario, public and private AGs must have territorial, legal and institutional frameworks within all urban policies that explore NBS.

Agroecological Peri-Urban Farming for Making Cities Liveable for All

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Urban areas expand at the cost of agricultural land. But a far more impacting process is related to abandonment of farming. Indeed, agricultural land abandonment has been identified as a major challenge in the EU-27. The trend is especially strong in peri-urban areas During the last 20 years, in Spanish metropolitan areas, as much as 30% of agricultural land experienced farming cessation with land following natural succession. I.e., in Madrid it accounts for over 2.700 has of areas cultivated in the past, that are now covered by meadows and pastures, by bushes and by forest areas. This process can be positive in terms of some ecosystem services, i.e., regarding the positive impact in the hydrological cycle and in the water quality. Nevertheless, if we open the scope of analysis, integrating other benefits and an opportunity cost in a context of increasing food insecurity, social inequity and spatial segregation. Therefore, we conducted research combining ecological, economic, and social indicators to assess different scenarios in the four largest Spanish metropolitan areas. Three main factors influence the assessment: a) after the global financial crisis of 2008, food insecurity became rampant even in high-income countries, over 13% of Spanish households are food insecure; b) large cities occupy fertile land best suited for food production. The results show that, in order to achieve a better balance of benefits in peri-urban

landscape, public policies should take into account not only land use but also the management practices operating. In the case of peri-urban landscape, combined social-economic and ecological benefits can be achieved if agroecological practices are adopted. Because they are intensive in labor (connected to inclusion employment), agroecological farming is well integrated with surrounding ecosystems, and it can be easily connected to short supply chains oriented to address urban demand for food, addressing food security and nutrition goals. This type of agriculture adapts well to the physical conditions of peri-urban metropolitan areas (i.e., to its characteristic spatial fragmentation) and would make it possible to contribute significantly to social and environmental objectives such as emissions.

Soil Mining and Climate Change: Drivers of Peri-Urban Trajectories Towards Uncultivated Land

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Conversion of land from agricultural land to build-up land in the hinterland of cities is one of among the most dynamic geographic processes and comes along with a loss of essential goods and services for human society, from food production to water regulation, and recreation framed as Urban Ecosystem Services (UES). While many studies have investigated the loss of soil surface to urbanization, activities such as soil mining, not only influence the area but also the quality of soil threatening the supply of other services. To fill this gap, we conducted a survey in the capital of Madagascar, Antananarivo, a city characterized by vast agricultural floodplains that is simultaneously confronted with urbanization and an increase in the severity of floods and droughts. We conducted 263 directed interviews, mostly with farmers and brick-makers, to assess the perceived UES change along a land-use trajectory from rice fields to urbanized land. Based on a basic statistical analysis, our findings suggest that synergies exist between UES where agricultural soil mined for brickmaking also increases water storage for flood regulation and water supply. However, intense soil mining depletes the topsoil layer down to the water table and degrades its capacity to be cultivated, turning the land into uncultivable land suitable for fish farming or urbanization. Furthermore, climate change and financial needs act as powerful catalysers of the peri-urban trajectory, as shorter rainy seasons and economic values of brick favors longer and more extractive brick-making campaigns. Our research illustrates that urbanization and increased demand in brick production as material of construction play a key role in the loss of essential UES. As claims for these UES are held by diverse stakeholders, future research should focus on supporting stakeholders in negotiating these diverse and often conflicting demands for soils towards the sustainable transformation of these areas.

Investigating Peri-Urban Farmland by a Mixed Spatial and Socio-Economic Approach Aiming at a Typology of Peri-urban Agro-Systems in Nairobi-Machakos Counties Interface, Kenya

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In a rapidly urbanizing world, peri-urban agriculture plays a multi-disciplinary role in cities' resilience, *i.e.* sustainable development, food security, livelihood, waste recycling and climate regulation in metropolitan regions. Farming in the peri-urban landscape is attracting more attention from various actors, including urban planners, policymakers, scientists, and multinational and local investors. However, farming activities in peri-urban landscapes in Kenya take on various forms and structures endowed with different factors related to urban and peri-urban landscapes. This paper aims to understand different farm types in the Nairobi-Machakos counties interface, map their spatial distribution in the peri-urban interface, and evaluate the underpinning factors of each farm type in the peri-urban interface. The paper implements a mixed spatial and socio-economic approach combining high-resolution Google Earth imagery with socio-economic investigation of 140 peri-urban farmlands and key informants' interviews. The spatial distribution of peri-urban farmland resulted in five farmland types *i.e.* residential gardens, small-scale open-field farming, large-scale open-field farming, small-scale greenhouse farming, and large-scale greenhouse farming. The analysis of socio-economic data using a factorial analysis of mixed data exhibited four distinct farm types. Farm types 1 and 2 combined residential garden, small-scale open-field and large-scale open-field, while farm types 3 and 4 encompassed the greenhouse farming systems. Determinant factors of PUA in the Nairobi-Machakos interface include PUA type, irrigation water source, presence of stream and land tenure system. The principal bottlenecks of peri-urban agriculture are water pollution, water scarcity, climatic variability, land accessibility, and high input cost. The findings provide insightful data for upscaling peri-urban agriculture in Kenyan metropolitan regions for food security, environmental sustainability and city resilience.

Peri-urban Agroforestry Heritage System. Past, Present and Future of the Mulberry-Dykes and Fishponds GIAHS Site of Huzhou City, China

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Peri-urban traditional agroforestry systems are considered a priority at an international level, as they serve as a link connecting cities and rural areas, providing local food and ecosystem services for people living in the cities. The mulberry-dykes and fishponds system (MFS), located near Huzhou city (Zhejiang province, China) developed as a consequence of the ancient flood control system created to protect local cities and villages from recurring floods. This system is recognized for its sustainability and for the strong functional interlinkages between the different components (mulberry trees, fishes, silkworms) by the Food and Agriculture Organization (FAO), which included it into the Globally Important Agricultural Heritage Systems (GIAHS) Programme in 2017. The research intends to measure landscape transformation in the last 12 years and to evaluate the effectiveness of the inclusion into the GIAHS Programme for land use changes mitigation. In addition, an accurate analysis of local planning has been performed to evaluate its capacity in protecting and valorising the site. Results demonstrated that MFS has undergone major land use changes in the last years due to urban sprawl, spread of solar panels (+7% in 2018–2021), and abandonment of the traditional mulberry-based system (−75% in 2009–2021). Other changes are related to the overall number of traditional fishponds (−81% in 2009-2018 and −33% in 2018-2021) and to their shape and size. Local planning tools are too sectorial, not enough integrated one another, and they do not consider the MFS as a single system. The study demonstrated that the inclusion in the GIAHS Programme is not sufficient to stop negative trends in the absence of adequate planning tools, even if it can contribute to slow them down, but it would be crucial to integrate the GIAHS action plan and vision into local planning tools.

Promotion of Urban and Peri-Urban Agriculture to Enhance Food Security and Reduce Urban Poverty to Dar-es-salaam Poor Communities

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Access to food is a basic human right. Our ability to determine our own access to food that is healthy, affordable, culturally relevant is part of that right. Food security means that safe and nutritious food is consistently available, accessible, and reasonably priced. The population of cities in Tanzania continues to expand exponentially. Like most of the cities of developing countries, feeding Dar-es-Salaam city, the largest city of Tanzania, in an ecologically sound, economically efficient and socially just way, is one of the biggest challenges of this century. Urban Agriculture (UA) is a process of using innovative scientific farming techniques to produce high yield and high quality of fresh organic food in very limited urban areas like backyards and open-spaces, all year –round. The concept of Urban Agriculture has gained the serious attention of Planners and Academic communities in Tanzania. Many people of Dar-es-salaam city are looking for opportunities to grow food in urban and

residential environments to increase access to healthy, local, and fresh food. In this paper, we study seventeen successfully functioning urban farmer groups in Dar-es-salaam, members to Tanzania and Environs Food Security, Urban Agriculture & Livestock (previously known as TaFoGa.Net), an Urban Agriculture and food systems membership NGO, registered in Tanzania to promote collective urban growers' access to spaces for food production; and creating systems for sharing knowledge transfers; promotes land sharing to increase its access to land and resources for urban agriculture; and creating new models for governance, coordination, and financing at Dar-es-salaam city and environs.

Promotion of Urban and Peri-Urban Agriculture (UPA) to Enhance Food Security to Poor Communities in Tanzania

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Access to food is a basic human right. Our ability to determine our own access to food that is healthy, affordable, culturally relevant is part of that right. Food security means that safe and nutritious food is consistently available, accessible, and reasonably priced. Cities obtain their food from a variety of sources, domestic and foreign, rural and urban. This paper highlights the experience as well as the importance of Tanzania and Environs Food Security, Urban Agriculture and Livestock organization, which promote collective urban growers' access to spaces for production; and creating systems for sharing knowledge transfers. The purpose is to promote land sharing to increase access to land and resources for urban agriculture for the need of creating new models for governance, coordination and financing. Mbeya City and Dar es Salaam environments are taken as the case study areas. The findings depict that the urban poor are experiencing difficulties in tapping into the formal food supply systems of both cities, regardless of how efficient such systems are. As the cities are urbanizing fast to attain 50%, the immediate surroundings are increasingly becoming key arenas for innovative interventions to reduce hunger, improve livelihoods, and mitigate and adapt to climate change. Indeed, urban agriculture is one of the ways to improve food security of urban households and to diversify their livelihood options through the urban agri-food systems that include production, transportation, and storage, processing and marketing. This is happening under conditions of persistent economic uncertainty and threats of climate change.

Morphological Characterization of Vitellaria Paradoxa (C. F. Gaertn) Under Different Land Management Regimes in Benin

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Vitellaria paradoxa is a semi-domesticated fruit species used for food, cosmetic and economic purposes. In view of the anthropic pressures on the species, it is important to consider its domestication. The main objective of this study is to evaluate the factors that influence the morphological variability of shea in Benin. A total of seven sites in two climatic zones of Benin were studied. Various pomological measurements (length, diameter and weight) as well as observations (shape and colour) were collected on 1500 leaves and 3000 fruits of the 300 sampled trees and subjected to statistical analysis. Five fruits shapes, four nuts and almond shapes and three shell colours were found. Among the 16 morphological parameters considered six are influenced by habitat type ($p<0.05$). The greatest variation was observed between individual shea trees (86% - 94.2%) and between habitats, shea parks and climatic zones. There is also a link between the morphological characteristics of the shea tree and the climatic variables considered in this study (rainfall, relative air humidity, mean temperature). Three distinct morphotypes were identified on the basis of quantitative and qualitative traits. The morphological characteristics of the fruits of morphotype 1 presents the interesting traits and can serve as a basis for improvement programmes of the species for its domestication in order to improve its productivity.

3. TRANSBOUNDARY EDUCATION OF LANDSCAPE AT DIFFERENT LEVELS

Potential of Sentinel-2 Imagery in Estimating Woody Vegetation Diversity in a Semi-Arid Ecosystem for Habitat Quality

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Woody vegetation is a significant indicator of habitat quality in heterogeneous protected areas. With an increase in population pressure as well as climatic changes, habitat quality is highly influenced by woody vegetation pattern changes. In Southern Africa, these semi-arid ecosystems play a vital role in combating forest degradation and enhancing biodiversity conservation. Earth observation techniques are useful in monitoring woody plant species diversity in heterogenous environments, however, the performance of satellite imagery in assessing woody plant species diversity in dry seasons has been understudied. This study aimed to assess the performance of diversity index, vegetation indices (VI) and land use land cover (LULC) derived from Sentinel-2 imagery to quantify woody plant species diversity in a savannah environment during a dry season. Analyses showed that; (1) Although NDVI performed better than MSAVI2, results showed it was better to use the MSAVI2 vegetation index to derive the LULC through the random forest algorithm with an 81% overall accuracy, 75% producer accuracy and 67% user accuracy. (2) Overall Shannon diversity index result was 0.3, with a maximum index of 1.36 and a minimum of 0.09 per transact. (3) The relationship of MSAVI to Shannon diversity index was statistically significant at 0.52. Additionally, the InVEST habitat quality model was used to analyze the spatial patterns in habitat quality per

LULC in the study area. Furthermore, results showed that the most contributing factor to overall habitat degradation was animal disruption to woody vegetation and animal grazing. (4) Pearson correlation coefficient showed that the relationship between Shannon diversity index, vegetation index and land use intensity is statistically significant at (r = 0.6) that warrants the use of these tools for environmental conservation. This study is critical to the conservation of biodiversity at woody vegetation scale as well as parks management in semi-arid regions and results from this study can be used by other authors to quantify multiple ecosystem services for sustainable biodiversity conservation.

Immersive Landscape Education: The Role of Virtual Reality in Fostering Participation, Collaboration, and Spatial Understanding

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The field of landscape education is continuously evolving, and educators are continually seeking new and innovative ways to engage students and enhance their learning experience. Virtual reality (VR) has emerged as a powerful tool to augment traditional teaching methods, and its potential in landscape education is yet to be fully explored. Virtual reality technology enables immersive and interactive experiences that provide an unparalleled opportunity for students to explore and understand the complexities of landscapes. Students can be transported to different locations, analyze landscapes from various perspectives and scales, and gain a deeper understanding of spatial relationships. Additionally, VR can enhance collaboration by allowing students to work together on landscape design and planning projects in a virtual environment as well as facilitate public participation by enabling stakeholders to contribute to the co-creation process. Through the use of VR, students can gain a deeper understanding of landscapes, and stakeholders can be more engaged in the design process, resulting in more inclusive and sustainable landscape solutions. It creates a shared experience that encourages communication and promotes creativity. This presentation showcases innovative approaches to incorporating virtual reality in landscape education. Outcomes of several experimental workshops, where virtual reality was used to understand spatial relationships and simulate different design scenarios, will be presented. The potential opportunities and challenges associated with implementing VR in landscape education and strategies for addressing them will be also discussed. This presentation highlights the transformative potential of virtual reality in landscape education and its ability to foster participation, collaboration, and spatial understanding.

Teaching the Ecosystem Service Concept: Experience from Academia

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Although ecosystem service (ES) is a well-established concept among the scientific community, it has not reached the mainstream of public awareness because it lacks wide recognition among citizens and educators. Teaching of ES may contribute to the mainstreaming of the ES concept and its framework in society in a critical and meaningful way, toward sustainable development. In fact, the ES concept is a key tool for communicating our social dependence on natural ecosystems, and therefore it has high didactic potential. However, this didactic potential is under-explored, because there is a lack of scholarship related to teaching the ES concept. There is little evidence, for example, on whether scientists who research ES also teach the concept and thus contribute to raising the level of ES awareness in society, and if so, how such teaching processes could be improved, to broaden the impact to citizen awareness. To close this knowledge gap, we delved deeper into how the ES concept is taught and which teaching strategies are currently being used by ES research academics. We aimed to establish connections between those teaching practices and best educational practices described in educational literature. This analysis will help to provide insights into academics' teaching approaches, as well as how these practices could be improved. A key finding of our research is that teachers with little experience in ES teaching are less likely to use active teaching methods or to evaluate their teaching (both related to best educational practices), whereas lecturers with more years of experience in teaching the ES concept are more in line with best educational practices. Therefore, collaboration and networking among teachers with different levels of experience could help improve the quality of ES concept teaching. We suggest the establishment of a platform to facilitate regular exchange among teachers and educators from different teaching contexts and educational levels. Finally, we propose several future research directions in this emerging research area in order to continue revealing the existing research gap in the teaching of the ES concept.

Gaps in Teaching Ecological Restoration in Secondary Education Across Europe and the Way Ahead

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The recent draft of the European Restoration Law shows the transnational relevance of ecological restoration manifested in governance. To restore landscapes in practice, education is needed on multiple levels, often also at the non-academic levels of the European Qualification Framework (i.e., in vocational education and training (VET)) to ensure implementation. However, recent studies have identified a weak diffusion of ecological restoration in VET. In TEAM#UP, we aim to mobilize extensive knowledge and skills from the third cycle in the field of ecological restoration to fill gaps in green VET. Thematically, TEAM#UP will address the following arenas across Europe: (1) multifunctional and sustainable land use in agricultural systems, (2) restoration of old infrastructure, ecological compensation and landscaping, (3) restoration across urban and rural landscapes, (4) forest restoration and disaster risk management. TEAM#UP will test different approaches to extend the realm of education on ecological restoration to secondary education. We will extend the use and creation of demonstration sites for ecological restoration both into secondary education and outside the ecological arena (e.g. agriculture, forestry). Methodological, we will explore options to train teachers to teach students to visualize demonstration sites with augmented/virtual reality approaches or to develop open education resources.

How to Benefit from Flipped Classroom in Landscape Education?

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This presentation aims at introducing to the concept and the educational model of Flipped Classroom. This model is not novel but it potential increased significantly considering the newly gained digital competences that the educational community gained during the COVID-19 pandemics. It benefits from the combination of virtual and face-to-face phases to enhance the learning experience of students. We share two experiments conducted in courses of green infrastructure planning in master education programme, both at the Universities of Munich and Lisbon, remotely and face-to-face. Three aspects are explored: (1) the communication of knowledge and how concepts and theoretical frameworks are provided to the students, (2) the interaction with student focusing on the apprehension of the knowledge by applying it to a specific landscape, and (3) how to approach and understand the landscape notably focusing on arising challenges in remote teaching setting. Ultimately, we aim at conducting structured interactive discussion with the congress participants about the strength and weaknesses of this teaching concept and explore its potential of applicability in other contexts. Specially having in mind the development of future partnerships for international interdisciplinary courses offered different universities across socio-ecological realities.

Landscape Trend of the Jasper Coast Tract (Southern Urals)

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The studies of the landscape Yashmovy Bereg tract revealed the negative impact of pastoral cattle breeding on vulnerable steppe landscapes. The purpose of the work is to identify landscape changes over the past 10 years on a plot area of 12 hectares. The tract has obvious signs of sutures, i.e. ophiolites (dolerite dikes and pillow lavas). Research in this area is carried out as part of the field practice of students of the University of SUSGPU under the guidance of Deryagin V.V. since 2006. On the ground, methods of landscape mapping using Garmin GPS Map are used, as well as interpretation of satellite images in the Google Earth program. Before the flood of August 2013, the dynamics of the landscapes of the Ural River valley was traced, caused only by moderate agricultural impact. Grazing was compensated by biomass growth. The flood destroyed all Lonicera tatarica and almost all Prinus Padus, damaging other stands. After the flood, the facies structure became simpler: half of the facies was destroyed. Because of this, the pasture capacity of the territory has decreased. The beach of the Yashmovy Bereg is an exceptionally convenient place for watering, in connection with which pasture digression has increased on the high floodplain and slopes of the volcanogenic massif. If until 2013 in most of the tract it was at the 2-3 stage, then the sandy deposits of the flood basically excluded this territory from pastures, and sheep and goats completed the destruction of the remaining grasses. The area under trees and shrubs decreased from 3.0 ha in 2012 to 1.6 ha in 2022. Flooding and a sharp increase in the number of livestock played a major role in the trend of loss of attractiveness of the Yashmovy Bereg. Strict regulation of grazing is necessary.

POSTER SESSIONS

Fencing Lands to Enhanced Climate Change Resilience, Promoting Biodiversity Regeneration and Improved Livelihoods of Climate Change in Makueni and Baringo Counties

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Kenya is a food insecure country, weather patterns are drastically changing, and people are losing livelihoods and earnings when their lands dry, water for domestic supply lacks and livestock die further frustrating livelihoods of the poor. This paper briefly discusses Fencing of lands as prerequisite to biodiversity protection and faster water retention mechanism, through tree planting, enhancing CO_2 sequestration as trees, shrubs and vegetation's find suitable environment to grow. Baringo and Makueni County are characterized by unsustainable agriculture, environmental degradation resulting from soil erosion, high poverty levels and food insecurity due to unpredictable dry spells and climate change. The present paper illustrates that Fencing of lands improves agricultural land management practices, biodiversity growth increased soil carbon sequestration. Trees also influence hydrology by absorbing, intercepting, and storing precipitation, and releasing water to the atmosphere through transpiration, maintaining ground water levels and reducing runoff. Trees are a source of food, shelter, and habitat for many organisms and soil erosion has contributed to desertification, growing water scarcity, and climate events such as flooding, storms and final loss of biodiversity. Fencing helps regeneration increasing soil biodiversity and organic matter, leading to more resilient soils that can better withstand climate change impacts like flooding and drought in Makueni and Baringo counties.

Do Afforestation Projects Increase Core Forests? Evidence from the Chinese Loess Plateau

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The spatial pattern of forests impacts on biodiversity, stability and sustainability of forest ecosystems. Afforestation and reforestation projects have massively increased forested areas on the Chinese Loess Plateau, however, the spatial pattern of the new and old forests, as well as their interaction, remains unknown. Here we studied the spatiotemporal dynamics of old and new forests for the period 2001–2016, using RS, GIS and Morphological Spatial Pattern Analysis (MSPA) tools as well as thin-plate smoothing spline method. We found that 84.21% of the old forests existed throughout the study period, and moreover, core forests (defined as a forest area which is surrounded by other forest areas)

significantly increased (2 585 km2 a−1, in total 39 597 km2). Two ecological restoration projects have left clear footprints on the forest landscape of the Loess Plateau: (1) The Natural Forest Conservation Project, aiming at expanding old forest, has resulted in the establishment of considerable areas of new forest surrounding old forest. Consequently, this has promoted new core forest areas to emerge. (2) The Grain for Green Project has mainly caused a fragmented landscape of forest islets which gradually connect to core forest areas. The general increase in core forest areas can be considered an ecological improvement, and the assessment method presented here may guide stakeholders in measuring the success of forest restoration activities that goes beyond a classical quantification of forest cover.

Characterizing 3D urban Landscape Change and Quantifying Its Effects on Urban Thermal Environments and Human Comfort

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Urban landscape changes exert a strong influence on urban thermal environments, and adaptation of urban landscape to cool urban environments has critical implications for urban sustainability. Previous research mainly focused on urban outward expansion, while the impacts of 3D urban landscape changes on urban thermal environments have been largely neglected. This study first analyzed the 3D urban landscape patterns in central Wuhan in 2008 and 2018, respectively, and then explored the characteristics of 3D urban landscape changes using multivariate clustering analysis based on differences in the landscape metrics between 2008 and 2018. Second, the gridded landscape metrics and other urban canopy parameters were incorporated into a mesoscale model coupled with an urban canopy model to quantify the impacts of 3D urban landscape changes on urban mesoscale thermal environments in central Wuhan. Results showed that the 3D urban landscape changes mainly took place between the 2nd- and 3rd-ring roads, and was mainly characterized by the vertical extension of urban space. The high-rise, mid-density expansion, the most intensive urban expansion mode in central Wuhan, led to warming of 1.3℃, drying of 0.6 g/kg, a decrease in wind speed by 1.7 m/s, and an increase in heat stress by 1.7℃ to a maximum extent through the day. The mid-rise, mid-density expansion had stronger impacts on air temperature, relative humidity, and human thermal comfort, but a weaker impact on wind speed than the low-rise, high-density expansion. Findings of this study help a comprehensive understanding of the impacts of urbanization on urban climate, and provide practical implications for urban landscape design and planning to improve urban living environments and sustainability in Wuhan.

The Growing Season in Zimbabwe Has Shortened Between 2000 and 2020.

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Climate change has been an issue of concern worldwide owing to, among other reasons, its direct impact on food security of the global population. Climate change alters the growing season, thereby leading to a shift in the areas suitable for crop cultivation. A characterization of the growing season is critical for the timing of farming activities such as land preparation and planting. The conventional methods of characterizing the growing period largely relied on meteorological station data. These however have challenges because of the sparse distribution of these stations. In addition, the datasets are often not consistent and up to date. This study used remote sensing, an alternative to station data, to map the spatial and temporal variations of selected growing season characteristics in Zimbabwe. The study was carried out using NDVI image products of SPOT-VGT sensor for the period 2000 to December 2019. Remote sensing software (SPIRITS) was used to analyze the data and to determine the spatial and temporal variations in the start and length of growing season in Zimbabwe. The results showed that there had been an alteration of the growing season in most parts of the country, with the drier regions being the worst affected. This alteration is characterized by a late start and an early end of the growing season, which leads to a shortening of the growing season. This study therefore concludes that the growing season characteristics in Zimbabwe are changing, owing to climate change and variability. This underlines the need to consider the changing characteristics of the growing season in future agriculture land use planning for food security. Overall, we have shown the utility of remote sensing in characterizing the growing season in Zimbabwe.

Using MicaSense Altum and CASI Airborne Multispectral Imagery for the Detection of Subalpine Grassland Mortality Events in the Hrubý Jeseník Mountain Range in the Czech Republic (Mountain Land

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Rapid climate changes strongly affect alpine ecosystems mainly due to altitudinal zonality. The southern part of the Hrubý Jeseník (Eastern Sudetes, Czech Republic) is not an exception: several large events of sudden grassland mortality have been observed there during the past two decades. Core subalpine grassland types (Nadrion strictae, Juncion trifidi), occupying heights of 1300 – 1491 m a.s.l., continue to be at different stages of recovery. We studied the potential of high-resolution airborne multispectral imagery for the quick and reliable detection and precise mapping of subalpine grassland health status: captured with drone-based MicaSense Altum 6-band camera (spatial resolution 0.075 m) and aircraft-based CASI hyperspectral sensor (spatial resolution 0.5 m), both taken in July 2022 at the peak of vegetation season. 450 reference points of damaged and healthy grassland were collected in the field at the same period of time. For detection, we calculated and compared statistics on spectral indices, recommended in the literature for non-photosynthetic biomass estimation. Those containing Red Edge band (LCI,

NDRE) have demonstrated the best results not only for dead biomass detection itself, but also for dead/living ratio estimation in coverage (LCI: R2 = 0.874, RMSE=0.037; NDRE: R2 = 0.851, RMSE=0.048). CASI-based LCI with threshold values 0.33–0.42 showed the best performance in distinguishing dead grasslands from degraded and wind-swept living grasslands (0.42–0.50) and bare land (<0.33). Moreover, 869-883 and 1012-1026 nm wavelengths of CASI appeared to be the most reliable to differentiate dead grass from dead wooden debris. On the whole, 17.3 ha (7.17%) remains covered by 50-100% dead biomass out of 241.4 ha of grasslands in total. This study was supported by an internal grant from the Technology Agency of the Czech Republic project no. SS03010065.

Local and Traditional Knowledge Restoration Techniques of Savannah Landscapes for Climate Change Adaptation, Burkina Faso.

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Land degradation is occurring in almost all terrestrial biomes, its impact is especially severe on the livelihoods of the poor, however local and traditional knowledge restoration techniques was a tool for recovering degraded land in the context of climate change and desertification. Land degradation is occurring in almost all terrestrial biomes and agro-ecologies, in both low- and high-income countries. Thus, the populations have developed traditional techniques (Zaî system, stone cordons, half-moons, etc.) to better manage water for agriculture in the face of its degraded lands. We refer to the literature review on local techniques and traditional methods of water and soil conservation, using cultural mapping which integrate Geographic Information Systems and social data. This article aims to map its different techniques, assess the impacts, the involvement of gender with social aspects and policies. The studies were carried out at the beginning of the rainy season in the village of Razoutenga. We therefore retain local and traditional water and soil conservation techniques that contribute to local and national economies, sequester significant amounts of carbon, strengthen food and clean water supplies and safeguard biodiversity. Local and traditional water and soil conservation techniques is strongly connected to sustainable development and contributes directly to UN Sustainable Development Goals 1, 2, 6, 13, 14 and 15, through: creating jobs and sustainable value chains; enhancing food security and dietary diversity; increasing water availability; supplying wood energy for cooking; mitigating the effects of climate change and enhancing the resilience of ecological and social systems. It can also contribute to Goal 16 by increasing the availability of natural resources. A policy brief is in perspective for taking into account indigenous and local knowledge in water and soil conservation policies.

Characterizing 3D Urban Growth in The City of Wuhan Using Time-Series Building Data

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Urban densification and outward expansion are two manifestations of urbanization. However, the spatiotemporal evolution of urban densification has been poorly understood. This study, using time-series building data covering the period of 2000 – 2018 in central Wuhan, is thus focused on this aspect of urbanization. We first show that building height, density, and volume increased substantially in this largest metropolis of Central China. However, building height in the urban core areas was usually smaller than the surroundings, while building density displayed a radial pattern with city center having the highest density. Second, multivariate clustering analysis was conducted to recognize five types of urban morphological zones. Type I (i.e., the highest density with medium height) was enlarged considerably around the city center from 2000 to 2018. Type IV (i.e., maximum height with high density) signified the most developed built-up areas, and it was increasingly found across the central Wuhan but not necessarily in the urban core areas. Frog leaping was the dominant urban expansion form in the early stage of urbanization, while infill and edge-expansion forms were prevalent during 2012 – 2018. Among the frog-leaping types, distant leap accounted for the largest proportion, followed by close leap. Finally, a positive spatial autocorrelation was found between building density/volume and the POI density. The high-high matched areas were found in the urban core areas, while the low-low matched areas mainly appeared in industrial zones. Findings of this study help a comprehensive understanding of urban land-change process, and have practical implications for sustainable urban landscape planning to promote synergies between urban structures and human activities.

Evaluation of the Long-Term Effects of Biological Legacy on Vegetation Recovery After Shallow Landslides Using Forest Landscape Models

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Shallow landslides are predicted to occur more frequently under climate change, due to an increased number of heavy precipitation events. Biological legacies left after disturbance (i.e., undisturbed vegetation patches, dead wood, and soils) play an important role in vegetation recovery. In 2021, we performed field surveys that revealed the short-term effects of biological legacies on species composition and vegetation recovery. However, their long-term effects remain unknown, but are important for appropriate forest management plans after landslides. In the present study, we investigated a forest in which large-scale shallow landslides (3550 ha) had occurred in 2018, and we simulated forest recovery following landslides using LANDIS-II, a process-based forest

landscape model, based on vegetation data of biological legacy collected in July 2022. We calibrated parameters and verified results with cross validation to represent the process of vegetation recovery. We simulated vegetation recovery in a 100-ha area for 100 years with two management scenarios: (1) removing biological legacies from forests and (2) leaving biological legacies in forests. We showed that the second scenario increased biomass recovery over 100 years and resulted in a species composition similar to that of the original forest before the landslides, which was likely to be due to the survival of late-successional species such as Japanese elm and Japanese maple. In conclusion, our study revealed that leaving biological legacy after landslides has significant potential to strengthen ecosystem resilience over a long period. Our results suggested the effectiveness of biological legacies to revegetation.

Assessing Impacts of Land Use Policies on Environmental Sustainability of Oasis Landscapes with Scenario Analysis: The Case of Northern China

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Oases in China are experiencing large-scale land use/cover change (LUCC), which profoundly affects regional sustainability. To improve sustainability, a series of land-use policies has been implemented. Can these policies effectively promote the sustainable development of oases in China? To answer this question, comprehensively examining the effects of the land-use policies on future LUCC and oasis landscape sustainability is urgently needed; however, such research is currently lacking. This study aims to evaluate the impacts of major land-use policies on future LUCC and the environmental sustainability of oasis landscapes. Taking the Zhangye Oasis as an example, we first developed 56 scenarios with different combinations of six land-use policies. Then, we simulated the LUCC between 2017 and 2050 under the 56 scenarios. Finally, we assessed the impacts of future LUCC on three key ecosystem services (ESs) and the water stress index. We found that the examined land-use policies could effectively control the sprawl of built-up areas, maintain croplands, and promote increases in forest and marsh, improving regional ESs. However, these policies will lead to an increase in water consumption, which will exacerbate regional water stress. Thus, these land-use policies cannot comprehensively improve oasis landscape sustainability. This paper systematically examines the impacts of six land-use policies on the environmental sustainability of oasis landscapes and reveals that these policies will increase ESs but cause further water shortages. Therefore, strengthening the integrated management of water and land resources is urgently needed to improve current land-use policies and oasis landscape sustainability in a more comprehensive manner.

Do Elevated Road Bridges Over Urban Rivers Create Flight Barriers for Birds?

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In cities with high-rise buildings, urban rivers are spaces with good visibility, making them easy to use as routes to foraging sites for birds. However, in metropolitan areas, elevated urban expressways and bypasses are sometimes constructed in the space above ordinary roads, so that when crossing a river, the bridge is like a two-tiered bridge. I conducted a study along the Horikawa River in Nagoya City, Japan, during the wintering season at four locations where roads cross the river by two-tiered bridges. Observations were made three times at each location for two hours after sunrise, and the height at which the birds passed the bridges and whether they changed their altitude before or after passing the bridges were recorded. A total of 5,076 birds of 22 species were recorded. Most of the birds passed over the elevated road at the altitude of the HH or H-zone (higher than elevated roads). Only a few passed through the M-zone (between the bridges). The L-zone was passed by ducks, Great Crested Grebes, and Great Cormorants, as well as herons and Kingfishers. Birds may increase their altitude before passing the bridge, but rarely decrease it. Although most of the waterfowl were basically moving directly above the river, many of Great Cormorants were moving along the river on the buildings in the HH-zone, and were taking shortcuts above the buildings and elevated road instead of using the canal directly above the canal to go to and from another river on the west side.

How Many Trees Can You See from Your Window?

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In the urban space, highly transformed by man and with a substantially reduced natural areas, man has limited opportunities to interact with nature. Therefore, each, even seemingly shallow, interaction with the living world takes on a special meaning. One of the examples of possible everyday interaction with nature in the city is experiencing/observing it through the window. The aim of this study was therefore to assess the provision of aesthetic experiences and opportunities promoting health, recuperation or enjoyment through passive interaction with urban trees from the place of residence or work. An indicator dedicated to the local scale and local spatial planning was developed, showing the number of trees visible from the windows (5 m facade segment) on the top floors of buildings. The preliminary analysis was performed for all residential and commercial buildings located in six selected housing estates in Warsaw, Poland: two tenement, two single-family and two large-scale multifamily. The mean number of visible trees ranged from 8 in the tenement housing of Śródmieście Północne to 277 in the large-scale housing estate in Chomiczówka. The obtained highest number of visible trees per window was 906, however, in every housing estate except Chomiczówka, windows/facades located on the top floors of buildings,

from which no trees were visible, were recorded. It can be concluded that the use of trees to generate aesthetic experiences and promote health, recuperation or enjoyment takes place to the greatest extent in large-scale housing estates, to a slightly lesser extent in single-family housing estates, and to the least extent in the areas of tenement housing. Nevertheless, the high variability within these residential types indicates that the land use in a given housing estate, both in the context of buildings and greenery, can substantially affect the use of this ecosystem service.

Landscape Focused; Collaborative Approaches Increase the Performance of Agri-Environmental Schemes for Biodiversity

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It is estimated that about 50% of Europe's wild species depend on farmland for part of their life cycle. Thus, protecting biodiversity in Europe cannot just be limited to nature reserves, but must include agricultural areas, too. Agri-environmental schemes have been implemented, with ecological focus areas (EFA) being a critical element. Three main types exist: (1) Action-based EFA (imposed management restrictions with a financial compensation for income foregone), (2) Result-based EFA (requiring a certain ecological quality, with a premium payment given), and (3) Collaborative EFA (set up by a group of farmers as an ecological network, with an additional financial incentive). To assess the effectiveness of each, plant species richness was analyzed at local and landscape scales on 3170 vegetation plots in 121 1-km2 squares in Switzerland. Results showed that collaborative EFA had the highest local-scale species richness, followed by result-based and action-based EFA, and by control sites. At the landscape scale, the percentage of plants, butterflies, and birds increased with the amount of collaborative EFAs. This suggests that creating a network of multiple farmers, who team up for a joint project, leads to higher biodiversity benefits, probably because of the more careful planning of the type and spatial allocation of individual EFA plots in order to foster specific target species and habitats. This justifies the higher transactions costs incurred in the process.

Investigating Connectivity-Conflict Interfaces and Safe Corridors Using a Seasonal and Multispecies Approach

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Connectivity across landscapes maintains ecological and evolutionary processes and is critical for wildlife viability. However, human-wildlife conflicts (HWC) often arise when wildlife moves into neighboring communities, causing human and wildlife mortality,

disruption of wildlife movements, and other losses for communities. Human population growth, habitat degradation/loss, and changing climate intensify competition among humans, livestock, and wildlife, further increasing HWC and negatively impacting conservation outcomes. This is especially true in Kenya, where most terrestrial wildlife is found beyond protected areas and live in coexistence with communities. Striking a balance between connectivity enhancement and HWC mitigation when managing Kenya's conservation network is therefore critical for the success of Kenya's conservation efforts. This study explores using data science and geospatial technology for sustainable landscape management. Focusing primarily on large mammals, we investigated connectivity-conflict interfaces (i.e., areas with high connectivity and high HWC) and safe corridors (i.e., areas with high connectivity and low HWC) using a seasonal, multi-species approach. Species distribution models for 28 most-observed large mammals were generated using MaxEnt based on presence observations from the Global Biodiversity Information Facility (GBIF) from 2010 to 2020 and 15 environmental variables associated with climate, topography, accessibility, land use, and vegetation cover while accounting for seasonality. We generated connectivity maps using Circuitscape and modelled HWC distribution across Kenya. Finally, we examined how HWC distribution overlaps with connectivity to identify connectivity-conflict interfaces and safe corridors, and the extent to which safe corridors are protected by Kenya's conservation networks. We will discuss our findings identifying areas important to connectivity and conflict, and where they overlap. Our preliminary examinations indicate that areas of overlap differ between seasons, with clusters occurring in the dry season and more dispersed areas occurring in the wet season. We will present and expand upon these findings and discuss our recommendations for conservation.

Mapping Terrestrial Vertebrates Climate Change Refugia for "30x30" Target in China

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Climate change poses a significant challenge to biodiversity conservation and should be addressed in the 30x30 Target of the Global Biodiversity Framework. Incorporating climate-change refugia into conservation planning can improve the effectiveness of protected areas (PAs). The identification of climate refugia as a potential area for biodiversity conservation has limited practical application, due to the lack of comprehensive research linking protection decisions to refugia, especially in terms of feasibility, and the focus on regions with strong protection foundations, while developing countries lack data and research capacity in this area. We propose a framework for risk-benefit-cost analysis aimed at identifying climate change refugia as potential sites for potential PAs and other effective area-based conservation measures (OECMs). We apply this framework in China, a megadiverse country sensitive to climate change, and identified (1) the first nation-scale map of climate-change refugia for biodiversity in China

for four categories of terrestrial vertebrates: amphibians, aves, mammals, and reptiles; (2) three types of conservation priority areas(CPA); and assessed (3) conservation effectiveness of current protected areas for refugia and CPA ; and (4) the proportion of conservation priority areas in each ecoregion and province in China. We found that 35.36% of China's territory has the potential to be protected as climate refugia, including the lower human impact Climate Priority Areas (CPA1) in protected area systems, which can increase the proportion of protected areas to 25.6%. Protecting all Climate Priority Areas (CPAs) through various means could increase the coverage of protected areas to 45.9%. Climate refugia are distributed differently from existing protected areas, with important climate refugia value in the relatively weakly protected southern region requiring enhanced protection. Amphibians and reptiles are more vulnerable to climate change than aves and mammals but receive less protection and therefore, require increased conservation efforts.

How Do Urban Park Features Affect Cultural Ecosystem Services: Quantified Evidence for Design Practices

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Cultural ecosystem services (CES) in urban parks are associated with nature contact willingness and health outcomes of urban residents. However, practical knowledge on how to manage urban park features to enhance CES is still lacking, especially on more detailed scales. This study developed a practice-oriented workflow for exploring design-related indicators that affect CES by considering four aspects of urban park features, including distance to elements, density of elements, land cover proportion, and landscape diversity. Then the workflow was implemented in a case study by taking six urban parks in Beijing as study areas. Three CES types were identified with outdoor social media images, including recreation value, aesthetic value, and social interaction value. Statistical analyses indicated that a combination of the four aspects of urban park features within a specific service radius was the most significant factor in explaining CES. The importance of design-related indicators for enhancing different CES types was also identified. Density of facilities, proportion of tree canopy-shaded ground, and richness of land cover types were proved important for all the three CES types and therefore could be concerned in urban park design practices. Based on these findings, this study further proposed landscape site design strategies and three adaptive design cases for enhancing different CES types, which could provide evidence-based and practical solutions for managers and landscape architects.

Nature-Based Solutions for Urban Heat Mitigation in Historical and Cultural Block: The Case of Beijing Old City

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Urban heat island can exacerbate the harmful influence on human health and urban environment in historical and cultural block within Beijing Old City, China. To improve urban resilience and human well-being, protect historical and cultural heritage, nature-based solutions for urban heat mitigation are being the hotspot of research. However, only few studies focused on the comprehensive thermal environment of historical and cultural block from the social, ecological and technical aspects. Thus, we set-up scenarios combining with the three domains, to explore the cooling effect and thermal comfort improvement of *Dashilar* Block through NVI-met. The results showed that 1) The areas with highest air temperature (*Ta*) and physiological equivalent temperature (*PET*) were mainly distributed in *Peizhi Hutong* and *Zongshu Toutiao*. 2) Five mitigation scenarios adapting to historical protection requirements and public preferences were vertical greening, traditional greening, quality improvement greening, high-albedo paving, and comprehensive. 3) The comprehensive and vertical greening scenarios could reduce the mean *Ta* of whole block by 1.01 ◦C or 0.38 ◦C, decrease the percentage of *Ta* hotter zone by 13.87% or 19.63%, and reduce the local *Ta* inside the block by 0.65◦C–1.80 ◦C or 0.33◦C–1.05 ◦C, respectively, which turned out the cooling effect and thermal comfort improvement of abovementioned two scenarios could significantly alleviate the heat stress. The comprehensive and vertical greening can act as the preferred nature-based solution for heat mitigation in *Dashilar* Block. We believed that this study would provide novel insights into the balance between urban heat mitigation and heritage protection during the renewal of Beijing Old City.

Uncovering Scale Effects on Spatial Patterns and Interactions of Multiple Cropland Ecosystem Services: A case Study in Eastern Coastal Hangzhou Bay Area, China

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Scale has a pivotal role in shaping ecological patterns and processes, and the features and interrelationships of ecosystem services (ESs) are both affected by spatial scales. Identifying scale effects of spatiotemporal characteristics of ecosystem services and relationships between them is crucial for achieving sustainable management of ecosystems and preserving human well-being, especially for cropland ecosystem with multiple functions closely linked to essential human needs. The primary objective of our study was to strengthen the understanding of the intricate interactions of diverse cropland ESs at multiple scales and to explore the impact of spatial scale on ESs and their relationships over the last two decades. We conducted our study in the Hangzhou Bay area of

eastern coastal China to analyze the spatial scale effects and temporal variations of cropland ESs supply, trade-offs/synergies, and bundles based on a multi-scale framework. The results showed that ESs had relatively stable spatial patterns and hotspots during 2000-2019, but converged towards homogeneity and aggregation as the scales increased. In terms of trade-offs/synergies in pairwise ESs, correlations were stronger and more synergistic at coarser scales compared to the finer scale. Three ESBs were delineated at all three spatial scales, which were relatively consistent in the average characteristics of ESs within them, but spatial heterogeneity and scale effects on their patterns were evident. These findings revealed variability in cropland ESs and their linkages across space and time, and highlighted the significance of spatial scales in studying regional ESs, which could provide an important reference for planners and decision-makers in proposing sustainable management strategies for cropland ecosystems and achieving improvement in multifunctional land use schemes.

An ES-Based Framework in Green Space Planning: A Case Study on Fengtai District in Beijing, China

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Green Space (GS) has become a crucial part of the process leading toward urban sustainability, because it provides a large number of ecosystem services that humans depend on. Planners and managers have therefore attempted to understand and improve GS multifunctionality. This study has characterized and mapped GS multifunctionality in Fengtai District of Beijing based on the ecosystem services (ES) perspective and has developed an adaptive model to improve its multifunctionality. The study has aimed to: (1) assess and map GS multifunctional degree, (2) characterize GS multifunctional types, and (3) propose adaptive solutions based on characterization of GS multifunctional types. Biophysical models and social questionnaires were used to quantify and map ES, ES hotspots, and ES bundles to identify the degree of multifunctionality and characterize GS multifunctional types. An adaptive model was designed to improve GS multifunctionality for local planning practice. Three GS multifunctional degrees from low to high were mapped. Seven GS multifunctional types were identified by the distinct heterogeneity of their compositions and function sets. These types of GS also implied different improvement strategies for GS planning practice. The adaptive model offers integrated solutions for preserving, restoring, and reforming levels that correspond to the characterization of GS multifunctional types. The ES-based framework proposed in this paper integrates multifunctionality analyses and can be helpful to urban planners in adaptive GS planning.

Construction of Multi-Objective Ecological Security Pattern Based on Ecosystem Service Trade-Offs and Human Preference

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Since socio-economic development has brought about ecological degradation and threatened human well-being, it's necessary to identify an ecological security pattern (ESP) that controls key ecological processes to help us prioritize conservation areas, thereby promoting sustainable management. Ecosystem services (ESs), influential indicators to assess the ecosystem's importance and human welfare, are widely used in ESPs' identification. However, the complex trade-offs and synergies between ESs and human decision-making preferences haven't been adequately considered in the ESPs' identification, which may lead to conflicts between multiple ESs and create challenges for optimal ESPs designing. Therefore, we propose an ESP identification framework integrating ESs trade-offs/synergies and human preferences from a nature-social composite perspective, which enables the identified ESPs to synergistically promote multiple conflicting protection objectives maximally while maintaining a relatively balanced configuration. In this paper, the Yangtze River Delta (YRD) was taken as the study area, five typical ESs including food supply, carbon sequestration, soil conservation, habitat quality and leisure-recreational were qualified, and their spatial heterogeneity and trade-offs/synergies relationships were revealed. On this basis, the ordered weighted averaging (OWA) model, a multi-criteria decision model, combined with geographic information was used to simulate the multi-gradient distribution characteristics under different decision preferences, aiming at balancing the conflict ESs. Then, ecological sources with the optimum protection efficiency and relatively low human-trade-offs were determined, thereby the ESP was optimized. Moreover, by emphasizing the importance level and the dominant function, this paper proposed criteria for ecological sources classification, aimed at rectifying the shortcomings of homogeneous ecological source management thus leading to more practical sustainable management. As a result, an ESP consisting of "multi-cores, one axis, two wings, five major regions" were designed for the YRD. In summary, our research framework has application potential to serve as an effective nexus between ecosystems and sustainable management practices.

Need for Structured Conservation Inputs: An Approach for Landscape Prioritization to Restrict Disturbance Regime in The Rajaji-Corbett Landscape of The Western Himalayan Region

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The population boom increases land-use requirements and minimal shrinking regions are available to preserve natural biodiversity. Unfortunately, scientific knowledge does not seem to have and might never get a correct solution to how much territory will be sufficient for satisfying the various biodiversity conservation goals. Prioritization of habitat, primarily for threatened species, is a critical management challenge. Habitat management efforts are gradually being performed over broader geographic regions, emphasizing the necessity of spatial and strategic prioritization. Habitat prioritization is a technique popular for identifying critical areas needing conservation initiatives. To develop a strategic conservation framework, key issues must be identified based on the ground knowledge and present land use status, which are difficult to gather for highly rough terrain areas. Incorporating spatial data sets thus helps to get the desired knowledge of the site on a large scale. In this study, we took a grid-based multicriteria approach to create a spatial conservation management framework for the Rajaji-Corbett landscape (RCL), Northern India. A grid-based prioritization assessment was conducted to identify priority areas for the RCL keeping invasive species and fire as a significant threat. The indicators or criteria were selected by looking at present vital concerns in the landscape. We took 20 indicators for our multicriteria assessment for landscape prioritization of RCL using 2x2 km grids for the evaluation and classified them according to low, medium, and high priority areas using ArC GIS Pro. The results identified 931 sq. km area of this landscape needs immediate management interventions where frequent fire incidents and presence of invasive species are high. RCL is well known for its biodiversity wealth and assemblage of various wildlife populations.

Exploring Multi-Taxa Based Ecological Indicators to Inform Riparian Integrity in a Tropical Watershed

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Riparian systems around the world are facing degradation due to anthropogenic pressure, affecting biodiversity, food and water security, and livelihoods. Adapting methods to assess riparian integrity locally and effectively is crucial to interventions such as habitat management and restoration. Riparian habitats being complex zones of transition between land and water, require careful consideration of both terrestrial and aquatic components. In this study we explored multiple taxa-based indicator approach to understand riparian integrity. Methods: We used plants, fishes and birds as representative taxa for terrestrial, aquatic and transition zones respectively. In addition, we assessed the water

chemistry, river discharge and width, and bank and bed characteristics. We used nested hierarchical sampling approach to select nine sites located on different streams in the Bhavani-Moyar watershed in Southern India. We sampled vegetation using quadrat method every 250 meters along a one-km transect, wherein we also sampled birds using point-counts. Fishes were sampled using catch and release method within a 150 m reach in the middle of the transect. Other parameters were also quantified every 250 m, except for water quality and discharge which were sampled at the fish sampling site. We adapted existing indices- fish-based Index of Biotic Integrity (IBI), Bird Integrity Index (BII), QBR (Qualitat del Bosc de Ribera)- Riparian habitat quality Index and disturbance index (DI). Results: IBI and QBR varied across nine segments and were found to be higher for protected areas as compared to human-habitation areas. DI for birds had the highest values in human-habitation areas. Four of the 44 candidate bird metrics responded to DI but BII showed patterns dissimilar to IBI. Conclusion: Fishes and birds respond to different disturbance elements and have unique habitat requirements. Single taxa-based indicators therefore failed to provide a complete picture of the riparian habitat condition.

The Use of LIDAR Data for the Classification of Cultivated and Abandoned Earth-Terraces Within a UNESCO Cultural Landscape

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With the increased availability of LIDAR data and technological advances, interest in high-definition morphological data for the study, evaluation and monitoring of landscapes has grown in recent years. With these new technologies, extremely detailed terrain models can be obtained, and analyses previously only possible with field surveys have now also become feasible remotely and on larger scales. One of the researches made possible concerns terraced areas, a topic that has gained increasing interest from the scientific community in recent years, both from a landscape point of view and for agricultural, geomorphological and water regulation aspects. This study aims to find a methodology to locate, assess and monitor the terraced areas, presenting a case study where these features are one of the constitutive characteristics, so much so that they represent one of the Attributes that allowed for the inscription as a UNESCO site: "Le Colline del Prosecco di Conegliano e Valdobbiadene". In this case study, the methodology presented is used to analyze the characteristics of Ciglioni, terraces supported by a grass escarpment rather than a dry wall, with the aid of a high-definition LIDAR survey (40 points per m^2). The analyses not only allowed the distinction of these areas from non-terraced areas, but also enabled their identification below the forest cover and the measurement of their structural characteristics. The analyses also made it possible to identify the main differences between the terraces dedicated to intensive, mechanically-assisted agriculture and those terraces characterized by more traditional uses. Analyses of this type are quite common at farm level, but with this methodology it was possible

to carry it out on an area of over 9000 ha, and it is possible to use the same methodology in other terraced area. Furthermore, this methodology allows the monitoring of individual structural elements of the landscape over time.

Landscape Integrity Assessment in The Olive Groves of the Slopes Between Assisi and Spoleto (Italy) GIAHS Site

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The olive groves of the slopes between Assisi and Spoleto are one of the most important sites for olive oil production in Italy since the Etruscan period. The site extends for about 9,200 hectares through six municipalities and is characterized by the compresence of drystone and earth terraces, built on the mountain slopes to allow olive tree cultivation during the centuries. These structures, resulting from the adaptation to the surrounding environment, created a cultural landscape of great aesthetic value and actively contribute to reduce hydrogeological risk. The quality of the landscape and the importance of the local agricultural system is also recognized by the inclusion of the area in the Italian Register of Historical Rural Landscapes of the Ministry of Agricultural Policies and in the GIAHS (Globally Important Agricultural Heritage Systems) Programme of the FAO. This landscape has been studied through the VASA (Historical and Environmental Approach) methodology, which is based on the comparison of land use maps of the same area at different historical periods; this methodology allows to measure landscape changes, trends, and the overall level of integrity, as well as to identify the main threats. The performed spatial analyses highlighted that in the period 1954-2021 about 50% of the total area remained unchanged, demonstrating that the local cultural landscape has not been subject to significant transformations and that the surface of traditional olive groves remained almost the same in the last 67 years. The applied methodology revealed that the hard work of small-scale farmers, together with the high quality of the final product, the role of rural tourism, and the valorization of the territory due to its inclusion in national and international programmes, can effectively contribute to preserve cultural landscapes and to counteract landscape changes that affected similar agroecosystems in Mediterranean countries.

Traditional Forest Management and Land Use Changes for Non-Wood Forest Products. The Case of the Traditional Shitake Mushroom Production in China and Japan.

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Non-Wood Forest Products (NWFPs) had and still have a key role for the economy of many rural areas, for their sustainable development and for preserving traditional culture, landscape and biodiversity. Two of the sites inscribed in the Globally Important Agricultural Heritage Systems (GIAHS) Programme of the Food and Agriculture Organization (FAO) are based on forest management specifically developed for shitake production: the Kunisaki Peninsula System (Japan) and the Qingyuan Forest-Mushroom Co-culture System (China). The aims of this study are to: investigate the landscape structure of the sites, assess the land use changes in the last 10 years, identify the main land use changes drivers. The methodology is based on the comparison of 2008 and 2019 land use maps, correlating the results with the altimetry. Results demonstrated that the maintenance of traditional forest management has effectively contributed to the preservation of two different but both traditional landscape structures, but the methodology allowed to identify some pressures that may affect the two GIAHS sites in the future. In the Kunisaki peninsula attention should be paid to the abandonment of agricultural surface (-4.3%) and consequent spread of grasslands (+63%) and forests (+1.3%), that mainly affect areas at altitudes lower than 200 m a.s.l. In Qingyuan County, deforestation (280 ha/year) and expansion of new cultivated lands (250 ha/year) represent the main changes, occurring along the main valley and, with less intensity, around the sparse rural settlements on mountain slopes; urban sprawl (+67%) also needs to be considered. Traditional forest practices represent effective examples of sustainable forest management; they are still able to provide high-quality NWFPs and ecosystem services to local communities, combined with the preservation of cultural landscapes and biodiversity, the differentiation of the income sources, new job opportunities, the preservation of local natural resources and of the local cultural heritage.

Disinfection of Treated Wastewater for Water Reuse - in search of the Safest Method for Humans and Ecosystems

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Water security and sustainability of water ecosystems may be in part maintained by water reuse. Treated wastewater provides an effective alternative for meeting the demands of agriculture and increase freshwater resources for other needs. Disinfection of treated wastewater protects the receivers. However, there are various hazards associated with handling disinfectants, some of the disinfection methods do not remove certain pathogenic and opportunistic organisms, and there is a risk of formation of harmful disinfection by-products (DBPs). Therefore, it is necessary to assess and compare the toxicity of DBPs produced as a result of various disinfection methods to select the safest one for humans and water ecosystems. The aim of the research was to compare the genotoxicity of treated wastewater from full-scale municipal wastewater treatment plant before and after the disinfection process with parameters ensuring satisfactory inactivation of

microorganisms. Three methods for wastewater disinfection were tested: ozonation, performic and peracetic acid application. Genotoxicity to *Escherichia coli* bacteria was tested with SOS-Chromotest. The influence on the genetic material of *Daphnia magna* crustaceans was determined by the Random Amplification of Polymorphic DNA - Polymerase Chain Reaction (RAPD-PCR). Treated wastewater before disinfection showed genotoxicity to *E. coli* and *D. magna*. However, although disinfected treated wastewater turned out to lose genotoxic potential to bacteria, it generated changes in the genetic material of crustaceans exposed to wastewater after the disinfection process. Significant decrease in the genetic stability of DNA in RAPD-PCR was observed, which increased with the extension of the disinfection time and the increasing concentration of the disinfectant. The conducted research confirms the genotoxic potential of treated wastewater before and after disinfection. Therefore, it may pose a threat to organisms of aquatic ecosystems when discharged into receiving reservoirs and reused in the event of water shortage.

Is It True that Nothing is Happening in Two of the Most Depopulated Regions of Spain. Do We Have to Care About Land Use Changes and Processes in These Areas?

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In the Global North main land use changes are associated with the increase of forests and the decrease of crops and pastures (Winkler et al., 2021). In Europe, the abandonment of agricultural land is related to processes such as intensification of productive land, conservation policies or the importation of agricultural products from other regions (Estel et al., 2012). Specifically, in Spain, different studies show the relationship between depopulation and land abandonment of certain rural areas, especially those located in mountain zones (Palacios and Silvestre, 2022). In this paper, a comparative analysis of land use changes occurred in the last two decades in two of the most depopulated Spanish provinces, Soria and Teruel, was carried out. These regions were, in 2017, among the 30 EU NUTS 3 least populated ones. With 8.7 and 9 inhabitants per square kilometer, respectively, one can refer to them as places where nothing happens. However, an analysis performed using the Corine Land Cover database shows records of 73% of total change in Soria and 66% in Teruel. Both provinces have similar dynamics of land use changes, with a very moderate urban growth, compared to the national dynamics, and where the greatest change corresponded to a naturalization of agricultural lands. These processes can lead in many cases to the abandonment of forest management, the loss of traditional landscapes and cultures, along with other issues such as the loss of biodiversity, increased erosion or the increase of wildfires, to name a few.

Modeling Agriculture Persistence After War-Induced forced Displacement and Depopulation. The Case of the Polish Carpathians After World War II.

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Armed conflicts can cause regime shifts in land use, but even when land use change is widespread, some areas persist in their land use. The question is what makes these areas more resistant. Our research goal was to find out what explains where arable farming persisted despite a major socioeconomic shock of forced post-WWII displacements. Our study area were 291 villages in the Polish Carpathians where abandonment due to the forced displacement of the Ukrainian population after WWII was widespread. We compared pre-war arable land with 1990 CORINE Land Cover data to quantify land-use change throughout the socialist period. We applied logistic regression with economically relevant environmental and access-related variables, and assessed the explanatory power of our models and relative importance of determinants. Forty years after forced displacements, arable farming persisted only in a small portion of what had been farmed in the 1940s (16%), while the majority of former arable land converted to forests (54%) or grasslands (22%). Arable farming persisted mainly in areas with high accessibility that had oak-hornbeam forest as potential natural vegetation, on less steep slopes, and at lower elevations. Our models predicting agricultural abandonment leading to reforestation performed well ($R^2 = 0.57$), but our model of persistent agriculture had low explanatory power ($R^2 = 0.26$) as did models of conversion to grassland ($R^2 = 0.24$). We therefore conclude that agricultural persistence is driven by different factors than agricultural land abandonment. In the long term, after arable farming ceases, areas can either be completely abandoned or convert to less intensive grassland use. These long-term changes have strong effects on biodiversity and ecosystem services. Our findings can help to develop strategies and policies for areas affected by agricultural land abandonment caused by armed conflicts and the related depopulation.

Responses of Tree Growth-Production Relationship to Forest Fragmentation

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Forest fragmentation is the most significant landscape pattern globally. Tree growth variation in forests of different levels of fragmentation provides useful information of the response of forest function to landscape pattern. Exploring the relationship between tree-ring data and the Normalized Difference Vegetation Index (NDVI) of forest coverage can better reflect the ecological effects of forest fragmentation. Based on the tree-ring samples and NDVI data of Picea

crassifolia Kom. on the west slope of Helan Mountain in Northwest China, we analyzed the responses of both tree growth and forest coverage to climate change along the elevational gradient, and explored the interannual relationship between tree growth and canopy productivity, and the underlying mechanisms through time series analyses. Our results indicated that, the average/max growth rate of tree rings is: mid-elevation > high elevation > low elevation; while for NDVI: low elevation >mid-elevation > high elevation. From low to high elevation, tree rings are increasingly restricted by temperature and gradually released from precipitation constraint. NDVI is also restricted to some extent by temperature from low to high elevation, and precipitation constraint is gradually released. The correlation between the two indicators is not significant in the low elevation, but a positive correlation was detected in the middle elevation, and a negative one revealed near the alpine treeline. Time lag of different lengths occurred in tree growth comparing with temporal variance in NDVI, 8-year negative at the mid-elevation, and 1-2 years at high elevation near the alpine treeline. The relationship between tree growth and canopy production revealed significant but differentiated responses to landscape fragmentation at the lower and upper forest boundaries.

Landscape of Sound - Influence of Social Public Information on the Landscape Connectivity and Occurrence of Amphibians in Habitat Patches

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Aim – There were many studies that addressed the relationship between the landscape structure, and animal occurrence and abundance in habitat patches. However, most of these studies do not take into account the influence of social public information. The aim of this study was to verify the importance of the social information (here – anuran mating calls) on the distribution of European anurans. Methods – We have surveyed amphibians in over 100 habitat patches in real landscape. We have used social information as a variable (indicating if a given pond is in range of amphibian voice propagation from other ponds) in models that were used to predict amphibian presence. Finally, we have compared fit of models with and without variables describing social information, verifying whether it increases models' predictive power. Results – We have found that using social information in distribution models enhances their predictive power. Results were most notable for (Fire-bellied Toad *Bombina bombina* and European Tree Frog *Hyla arborea*). Conclusions – It is our hope that this could help to alleviate the detrimental effects of habitat loss and fragmentation on amphibians via implementing mitigation measures such as emitting voices of

conspecifics at empty suitable habitat patches during the breeding season to attract migrating individuals.

Promoting Sustainable Carbon Sequestration of Plants in Urban Greenspace by Planting Design: A Case Study in Parks of Beijing

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Urban greenspace has been highlighted as a means of offsetting carbon dioxide (CO_2) emissions and mitigating climate change in cities. However, it is still challenging to design for sustainable carbon sequestration. This study developed a transdisciplinary framework to link carbon sequestration research with planting design practices. Taking 28 urban parks in Beijing as a case, we integrated field investigation and remote sensing images to analyze the relationship between planting design indicators and carbon sequestration efficiency, and the change of carbon sequestration efficiency with the growth of plant biomass. The results showed that carbon sequestration efficiency varied over the urban parks with a mean value of 8.72 gC m− 2d -1, and varied with plant growth. The difference was associated with individual plant properties and biotope structure. Medium-sized plants and biotopes with partly open structure are proved cost-effective for sustainable carbon sequestration of urban greenspace. We summarized adaptive planting design strategies for different biotope types and emphasized the benefits of nurturing growing and partly open biotopes structured with different sizes of plants. The results will be possible to produce information for landscape architects for improving sustainable carbon sequestration not only in the study area but also in other cities with similar climatic characteristic.

Assessing Impacts of Landscape Change on Ecosystem Services in Sub-Humid Zimbabwe

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In many parts of Zimbabwe, smallholder farmers are facing food insecurity compounded by a gradual degradation of their nearby environment. In communal lands of the Murewa district, agropastoral landscapes are changing fast, challenging the provision of ecosystem services and therefore food security and well-being. In this context, the landscape level can be an interesting approach to gain a holistic understanding of ecosystem services and disservices. The objective of this study is to identify i) drivers of past and on-going landscape change in Murewa and ii) how these changes affect ecosystem services and disservices. We are developing an innovative approach that combines land use and land cover change (LULCC) modelling and ecosystem services and disservices mapping. We conducted qualitative interviews and participatory mapping with local actors and produced maps of LULCC

using remote sensing time series. We found that a substantial share of the arable land has been left uncultivated, while newcomers now settle in collective areas, such as wetlands and woodlands, increasing the pressure on natural resources. We identified seven drivers of LULCC, including demography, economic trends and climate change. We then identified 10 ecosystem services and disservices, including fertility transfers between landscapes units for food production, firewood for fuel, erosion control, water pollution and pest control. We then build a spatial LULC model (based on the drivers identified) and combined it with a quantification of ecosystem services per land use. The simulations will help measure and quantify the impacts of the drivers of land use change on ecosystem services and disservices. The model will then be used in a foresight approach to identify possible landscape configurations that optimize the supply of ecosystem services and its match with local demand. Our study will provide insights for decision makers to design actions that improve the sustainability of landscapes.

Mapping Fine Scale Differences in Mosquito-Borne Disease Risk Using Remote Sensing

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Mosquito-borne diseases (MBD) threaten over 80% of the world's population, and are increasing in intensity and shifting in geographical range with land use and climate change. Mitigation hinges on understanding disease-specific risk profiles, but current risk maps are severely limited in spatial resolution. One important determinant of MBD risk is temperature, and though the relationships between temperature and risk have been extensively studied, maps are often created using sparse data that fail to capture microclimatic conditions. Here, we leverage high resolution land surface temperature (LST) measurements, in conjunction with established relationships between air temperature and MBD risk factors like mosquito biting rate and transmission probability, to produce fine resolution (70 m) maps of MBD risk components. We focus our case study on West Nile virus (WNV) in the San Joaquin Valley of California, where temperatures vary widely across the day and the diverse agricultural/urban landscape. We first use field measurements to establish a relationship between LST and air temperature, and apply it to Ecosystem Spaceborne Thermal Radiometer Experiment data (2018–2020) in peak WNV transmission months (June–September). We then use the previously derived equations to estimate spatially explicit mosquito biting and WNV transmission rates. We use these maps to uncover significant differences in risk across land cover types, and identify the times of day which contribute to high risk for different land covers. Additionally, we evaluate the value of high resolution spatial and temporal data in avoiding biased risk estimates due to Jensen's inequality, and find that using aggregate data leads to significant biases of up to 40.5% in the possible range of risk values. Through this analysis, we show that the synergy between novel remote sensing technology and fundamental principles of disease ecology can unlock new insights into the spatio-temporal dynamics of MBDs.

Combined Terrain and Canopy Complexity is a Good Predictor of Multitrophic Biodiversity.

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Understanding the relationship between structural complexity and multi-trophic diversity is crucial for effective land management and biodiversity conservation. However, current methods for evaluating multi-trophic diversity can be costly and time-consuming, leading to its often-overlooked role in land management decisions. Here, we 1) developed a multi-trophic diversity index, 2) explored a new method to quantify structural complexity based on widely available remote sensing data, and 3) investigated the relationship between structural complexity and multi-trophic biodiversity (bird, beetle, and land plants) at the landscape scale. We conducted our study using data collected from 34 forested sites of the National Ecological Observatory Network from 2013 to 2022. We studied the influence of vertical (rugosity, maximum canopy height, mean maximum canopy height, entropy, and vertical structural complexity), horizontal (cover fraction, deep-gap fraction, rumple, and vegetative area index), and terrain (slope, mean elevation, terrain roughness, and topographic ruggedness index) structural complexity of forest canopy on multi-trophic (primary producers (plants), herbivores (beetles), and omnivores (birds)) diversity in 34 forested ecosystems. We used plant presence, beetle pitfall trap, and bird count data to calculate species richness and species diversity, and high-density LiDAR data to calculate structural complexity metrics of forest canopy. Our results indicate that multi-trophic species richness and diversity across all trophic levels generally increase with increasing vertical, horizontal, and terrain structural complexity, with the highest diversity observed at intermediate levels of structural complexity. However, we also found that these relationships differ across deciduous, mixed, and evergreen forests.

Mapping Burn Severity in the Aberdare Range, Kenya Using Landsat OLI-2 and Sentinel-2A Data

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The Aberdare Range in Kenya's Central Highlands has several fire prone vegetation types including moorland (above 3300 meters). Kenyan news media reported a major fire in the Aberdare Range burning from 06 February to around 20 February 2023 and estimated that about 40,000 acres (over 16,000 ha) burned in the fire. In this study, we used Landsat 9 Operational Land Imager 2 (OLI-2) from 04 February 2023, 20 February

2023, 08 March 2023 and Sentinel-2A data from 28 January 2023, 22 February 2023 to calculate Differenced Normalized Burn Ratio (dNBR) and Relative Differenced Normalized Burn Ratio (RdNBR). Burn severity ranges for dNBR and related indices were developed in other regions of the world (i.e., western forests of the USA) and band wavelength ranges differ between earlier Landsat instruments (Thematic Mapper and Enhanced Thematic Mapper Plus) and current sensors. We aim to determine if these ranges apply to these instruments and vegetation types to enable more automated burn severity mapping of Kenya wildfires. Since we don't have field-based burn severity data for this recent fire, we're using image data and field checked severity for recent fires in Chyulu Hills to determine severity of the recent Aberdare Range fire. Our preliminary analysis of Sentinel-2A data shows that the total burned area was 14,263.52 ha, with 39.8% low severity, 60.2% moderate, and 0% high severity. From the more recent Landsat OLI-2 data it is also clear that additional areas burned after late February.

Landscape Change at Mt. Kasigau in Taita-Taveta County, Kenya Using Landsat and Sentinel-2 Data

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Mt. Kasigau forms the northeastern limit of the Eastern Arc Mountains that have been described as discrete islands with localized areas of high rainfall surrounded by comparatively arid woodland. The mountains are noted for their high species richness, high concentration of endemic species, and highly fragmented condition. Multi-temporal Landsat and Sentinel-2 images were classified together with ancillary data using several classifiers and training data obtained through fieldwork and interpretation of WorldView-2 and Google Earth images. The eight vegetation classes targeted for mapping had previously been identified through classification and ordination of vegetation data from 55 sample plots. Land use/land cover (LULC) maps for three time periods: 1999-2001, 2010-2012, and 2021-2023 were generated. The neural network classifier with adaptive boosting, and the Random Forest classifier resulted in the highest classification accuracies, with Kappa coefficients of 0.880 and 0.876, respectively. The seven vegetation types abundant on the mountain covered about 3,300 ha. Landscape metrics for these vegetation classes were computed to help quantify landscape change. Post-classification comparisons used to identify broad changes that had occurred over the three mapping periods. The largest LULC changes observed occurred in the plains below the mountain, with agricultural expansion and reduction in bushland vegetation the most prominent. Vegetation changes on the mountain were less obvious with only a slight decline in the semi-evergreen woodland and montane woodland classes, and increased patchiness. Spectral mixture analysis was used to identify the subtle changes that had occurred within the montane vegetation classes.

Funding Mechanism for Supporting Small and Medium-Sized Companies to Join Ecosystem Conservation in Local Cities in Japan

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The many challenges associated with climate change are having profound impacts on all business sectors. Economic systems are needed to be transformed to enhance the sustainable use of natural capital. The Task Force on Nature-Related Financial Disclosure (TNFD), launched in 2021 along with the movement toward "Nature Positive," forces global companies to disclose their contribution to natural capital and make investment decisions based on this information. In local cities of Japan, however, awareness of the crisis has not been widespread enough, because there are only a few global companies, and most are small and medium-sized companies (SMCs). The objective of this study is to identify financing mechanisms and the role of regional finance companies in supporting the participation of SMCs in ecosystem conservation in local cities. In 2015, the Japan Securities Dealers Association (JSCPA) created a new financial system, called "Shareholder Community (SC)". The SC aims to support the financing of growth companies and the promotion of community-based activities among SMCs. Transactions are limited to community participants. Securities firms designated by the JSCA examine companies that want to join the SC from the financial condition and ensure its accuracy. In Tokushima Prefecture, "Tokushima Godo Securities Co., Ltd." (TGS), which has a philosophy of contributing to the conservation of local biodiversity, has been designated as a securities firm. TGS certified Hiyori Farm, an organic JAS-certified agricultural corporation, as the first SC. The area where Hiyori Farm is located has been selected as one of the 500 most important wetlands in Japan by the Ministry of the Environment, and the rice paddies have functioned as alternative habitats for many endangered aquatic plants. Continuing rice cultivation leads to the conservation of those species, and thus TGS can contribute to the conservation of biodiversity by using the SC system.

Poster Session III

Sustainable Recovery of the Mangrove Forest Based on Productive Landscape

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As one of the most diverse ecosystems in the world, mangroves have a positive effect on the development of the city, such as wind and wave protection, the promotion of silting, and the bank protection. It is a special ecological system for the transition from land to the sea. However, this ecosystem is being seriously threatened due to the pressures of urbanization, land exploitation and economic development. This study took Pearl River Delta in Shenzhen, China as an example,

analyzed the problems of disappearing mangroves caused by the aquaculture. Through the monitoring of different combinations of agroecological models, some feasible methods to balance the habitats preservation with land exploitation could be proposed. According to mangrove's characteristics and water environment of the experimental site, it is suggested to transform the aquaculture ponds into productive landscape, via building base peri aquaculture system. In this case, a symbiotic relationship between mangroves and aquatics would be built, and the gradually sustainable recovery of the mangrove forest would be great potential.

Comparison of Low-cost UAV Methods for Vegetation Mapping in Rewilding Landscapes

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Vegetation mapping is a critical element in monitoring conservation efforts in rewilding landscapes. Unmanned aerial vehicles (UAVs) have gained popularity as diverse, adaptable and dependable tools for managing natural ecosystems. The UAV technology and onboard sensors have diversified exponentially over the last few years. However, do managers need to invest in expensive high-end systems and highly trained personnel to get the necessary information? Moreover, what is the most valuable data one can acquire with low-cost systems? This study addressed the following questions: a) does RGB image compression affect classification accuracy? b) is classification accuracy significantly different between RGB and multispectral sensors? c) How does the multi-seasonal RGB dataset compare to single-season multispectral image classification? The above questions were investigated in two 5-ha plots in the Greater Côa Valley (Rewilding Portugal). We used a consumer-grade UAV (DJI Phantom 4 and onboard RGB camera) and a Parrot Sequoia multispectral (MSS) camera. RGB data (~5cm resolution) were acquired over three consecutive seasons and MSS (~10cm) in early spring. Orthomosaics, Canopy Height Model (CHM) and Vegetation indices were produced in Structure from Motion in Pix4D software. Vegetation was classified into seven dominant lifeform classes in OBIA using the Random Forest algorithm. Uncompressed RGB images generated better overall classification accuracy (OA 80.65%, kappa 0.77) than compressed RGB images (OA 62.04%, kappa 0.54). Multispectral images had higher classification accuracy than RGB data (OA 85.19%, kappa 0.83). The best accuracy was obtained from tri-seasonal RGB images (OA 92.99%, kappa 0.91). The study also emphasises the importance of GCPs in multi-temporal image alignment. The study concludes that low-cost methods can provide valuable data to map vegetation and support monitoring protocols in conservation management. These can be used to track changes caused by the grazing regime of herbivore population in rewilding landscapes such as the Greater Côa Valley.

Am I My Brother's (River)Keeper? Transformative Change through Community-Based Stream Restoration

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Stream restorations are a popular, if sometimes controversial, method to clean polluted waterways. To meet regulatory requirements to reduce pollution to the Chesapeake Bay, the government of Richmond, Virginia, USA has committed to restore thousands of linear feet of streams within the metropolitan boundary. Several initial project proposals by the city were met by strong community resistance, and efforts at those sites were eventually abandoned. We describe an active restoration that illustrates the potential for these projects to do more than just remove sediment and nutrients but transform long-ignored portions of the city. Our restoration project began as a unique collaboration among city government, a university, an ecological restoration company, and a landscape-design firm. Community engagement subsequently broadened in establishing a shared plan for the design, maintenance and monitoring of the restored stream. The plan was extended to create a multifunctional landscape honoring the ecology and the cultural history of the site. The benefits of community-engaged design included building local capacity, leveraging creative energy, and engendering a strong sense of spatial agency among diverse user groups. We describe novel approaches to the landscape planning process including with the ecological design principles and studies of the historical legacy of enslavement on the land. Cultural resource excavations occurring side-by-side with invasives species treatments necessitated holding space for multiple vision of the past, present and future of the landscape. Taking lessons from the water that change is constant, we document the evolution of the stream structure and function, but more generally the emergence of new strategies to connect people to the land in this new "Eco-Corridor."

Mammalian Species Richness in a Multiuse Landscape: Identification of Drivers and Opportunities for Expanding Conservation Area Network

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Re-Evaluating Success in Transboundary Fisheries Management: Pacific Halibut a Case Study

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Transboundary fisheries which span multiple exclusive economic zones (EEZs) are at higher risks for overexploitation currently and at an increasing rate in an uncertain climate future. Furthermore, capture fisheries remain highly inequitable amongst ocean sectors. The shift toward the Blue Economy paradigm as a new model of sustainable coupled human and natural oceanic systems necessitates that modern ecosystem management of fisheries accounts for the cost-benefit sharing of fishery resources required to meet sustainable development goals and build resiliency within management systems. Recent efforts have been made to understand how fishery management strategies affect fishing communities but equity assessments are still missing from many management structures. This study aims to evaluate the equity structure within transboundary fisheries using the Pacific Halibut (Hippglossus stenolepis) as a case study with the explicit goal of assessing the "measure of success" within management strategies. The effectiveness of community participation in fishery management, the utility of quota allocation, and the benefits of community-based research were all evaluated through a methods portfolio approach including a literature review, economic assessment, and seascape ecology analysis. Preliminary results indicate that despite these efforts to boost equity within the fishery, community participation within the fishery has declined significantly over the last several decades as barriers to enter the fishery continue to rise. Meanwhile, the commercial quota consolidation within the fishery has led to a less diverse portfolio of fishers and consequently, a system less resilient to the inevitable disruptions of climate change. These findings highlight the conceptual gap in definitions of success that present a barrier to equity and community inclusion as a fundamental goal of fisheries management.

Drivers of Soil Microbial Biomass and Community Composition across Broad Spatial Scales and Diverse Land Cover and Land Use Types

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Holistic landscape management requires understanding the relationships between soil microbes and above-ground variables, such as plant communities and land use. The dynamics between soil microbes, land cover, and land use have been explored in fine-scale studies, but not at regional and continental spatial scales. Thus, we used data from 41 terrestrial sites across the United States from the National Ecological Observatory Network (NEON) to identify explanatory drivers of soil microbial biomass and community composition at broader scales. We used phospholipid fatty acid (PLFA) as a response variable for microbial biomass (n=3,752) and tested the NEON leaf litter, vegetation, climatic, and soil physicochemical data to identify the most important drivers of microbial dynamics. Random forest analysis indicated that soil moisture, pH, % sand, and mean annual temperature were the most important predictors of microbial biomass at the continental scale. Plant diversity and percent coverage were not important

factors at this scale, yet land cover types differed significantly in microbial biomass according to ANOVA and Post-hoc Tukey HSD tests ($p < 0.01$). Dwarf/scrub and sedge herbaceous plots had the highest levels of biomass possibly due to optimized soil moisture and cooler climates, while pasture/hay, cropland, and shrub/scrub plots were biomass-poor as a consequence of multiple constraints that require additional modeling. Per multivariate analysis, pH was also an important driver of microbial community composition, but diverging from biomass results, the C:N ratio was of equal importance for microbial beta diversity. Our results call for further research on soil responses to climatic stressors and land management. Specifically, the relationship between soil moisture and microbial communities warrants further investigation. Extreme precipitation may alter microbial communities and their corresponding functions; thus, studying microbial dynamics under diverse irrigation technologies and land cover categories may be critical research areas for improving ecological resilience.

Assessment of Landscape Resilience to Climate Change Impacts as a Tool for Planning Process for Self-Governments (Model Area - Bratislava Self-Governing Region, Slovakia)

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The interested area (one self-governing region in Slovakia) with an area of 2 052,7 km2 was evaluated in terms of resilience to the impacts of climate change. The area of interest was the urban-rural landscape including the capital of Slovakia (Bratislava). The steps of the applied methodological procedure are based on the essence of data collection, data processing, map calculations and attribute operations which represent a fundamental input into decision-making processes at the level of spatial planning in self-government. The evaluation resulted in the measures in the form of planning regulations at regional level. The aims of these proposals are to improve the quality of spatial structure of landscape, strengthen the ecological stability of the territory, support the management of Eco stabilization landscape elements (nature-based solutions) and mitigate the negative impacts of climate change. The measures were processed and published online as spatial data.

Governance and Resilience of Communities on the Fringes of Atewa Range Forest Reserve (ARFR) in Ghana

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Protected areas constitute one of the viable tools that countries like Ghana can count on for securing and conserving environmental, social and economic capital. The Atewa Range Forest Reserve (ARFR) is a unique and

exclusive ecosystem reserve and recognized as a Special Biological Protection area and a Globally Significant Biodiversity resource area. The issues of deforestation and forest degradation continue to be the bane of communities living on the fringes of reserved forest and other protected areas. Hardins (1968) asserts the use of force alone will not deter people from contravening the forest laws and the management of commons as this landscape. It is imperative that the establishment and effective governance of ARFR merit considerable attention. The study objectives were to determine why specific laws and regulations are needed in managing such a landscape. From these laws and regulations would emanate 'requirements' that spells out specific practices and procedures to directly or indirectly reduce water evaporation. A compliance and enforcement program that is effective and part of a larger environmental management effort will bring a variety of benefits to society. The study relied on both primary and secondary data. Methodology included stratified, purposive sampling methods , personal observation and practice were used. The rural poor have a unique and special relationship with ecosystems that revolves around the importance of these natural systems to rural livelihoods. Livelihood is used to express the whole complex of factors that allow people to sustain themselves materially, emotionally, spiritually, and socially. The motivating factors that induce or drive people to deforest and degrade the forest and the environment are pushed by factors as poverty, agriculture, population increase and climate change.

Impact Assessment of global Megatrends on Landscape: Case Study of Danubian Lowland.

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The resilience of stability of individual countries is and will be significantly affected in upcoming decades by various global megatrends The topic of global megatrends (GMT) focuses several of the most urgent and important issues humanity is currently facing. In the 2015 report, the European Environment Agency identified 11 GMTs, which are thematically divided into five clusters: Social cluster, Technological cluster, Economic cluster, Environmental cluster and the Cluster of governance and diversifying approaches to governance. Solutions for such complex issues can only be achieved through political cooperation and subsequent creation of international treaties and legislation based on accurate scientific evidence, research and thorough understanding of the drivers and impacts of mentioned trends. The thematic diversity and extensiveness present a difficult obstacle to the assessment of GMT's impacts. This fact causes works focused on global megatrends to often examine their impact on specific, narrowly specified areas. Evaluating the impacts of GMT's on the landscape, which is also a complex system is even more difficult. It requires an interdisciplinary approach. Our approach therefore focuses on the fundamental driving forces behind these trends and considers their impact in a nexus of individual GMT's. The poster presents methodology for assessing the impacts of GMT's on the landscape and its application in the study area - Danube region. Study

area is situated in the south-western part of Slovakia - Danube Plain. The total area of the territory is 46132,5 hectares. Its northern part, where the Bratislava city is situated, has prevalent urban character. The rest of the region of interest is significantly more agricultural with smaller rural municipalities and there are also preserved ecosystems natural to this Danube River sub-basin. This varied natural-socio-economic complex predetermines it to be a suitable study area for assessing the impact of GMT´s on the landscape.

Landscape Metrics and Conservation Perspectives for Insulated Parks in the City of São Paulo, São Paulo State, Brazil

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The municipality of São Paulo (São Paulo State, Brazil), from the 1970s, presented a rapid expansion of its peripheral area that resulted in the loss of its original vegetation cover. The vegetation cover was reduced to fragments isolated by the process of urbanization expansion. These remnants have a presence of secondary natural vegetation of the Atlantic Rain Forest, which used to occupy a good part of the territory of São Paulo and that gave rise to today's metropolis. In an attempt to protect these remnants, nature conservation units were created in the urban landscape, such as the Parks. The Parque Estadual Fontes do Ipiranga, Parque Estadual do Jaraguá and and the Parque Natural Municipal Fazenda do Carmo are located in a non-municipal situation of São Paulo: they are integral protection units that keep remnants of forest in relatively small areas and are isolated in densely urbanized regions. In this sense we worked with a hypothesis of an isolation condition subjected these environments to situations that threaten their conservation in long term. From this perspective, this study discusses how a landscape structure can influence the conservation of forest remnants protected by Parks that are in isolation. The parks that must guarantee the minimum interference of human activities face great difficulties in effectively fulfilling their function as integral protection unit in urbanized environments, existing a conflicting relationship between urbanization and conservation. The hydrographic basin was defined as a unit of analysis for this study, because it is a natural region and also encompasses the surroundings of the Parks: a basin of the Ipiranga stream, which is a tributary of the Tamanduateí river, was selected for presenting in its perimeter Parque Estadual Fontes do Ipiranga. As watersheds of the Vermelho and São Miguel streams and the Santa Fe stream cover an area of the Parque Estadual do Jaraguá ; And, a watershed of the Aricanduva river, counts on presence in the Parque Natural Municipal Fazenda do Carmo. Land use and land cover maps were prepared for a reconstruction of the river basin landscape and for the identification of the changes brought about by the urbanization process. Photographs were made of areas from the years 1962 and 1994, and, Images of the Rapid Eye satellite to perform the mapping; And, later, metrics of the landscape were generated to analyze the present and preterite situation of the forest remnants present in the

hydrographic basins. It was based on the theoretical assumptions of Landscape Ecology, observed how changes in land use and coverage and the urbanization process interfered in the dynamics and ecological conditions of forest remnants protected by Parks in the city of São Paulo. With an analysis of the data obtained from the landscape metrics, it is possible to establish as main tendencies and prognoses for the conservation of the losses and to discuss possible actions to soften the isolation and to improve the ecological conditions of the remnants.

Effects of International Boundary Making on Pastoralists Transboundary Environmental Resource Use in the Ethiopia-Kenya Borderland

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The international boundary in the Ethiopia-Kenyan border does not consider the livelihood and customary practices of local people. Ethiopia and Kenya have ethnic groups living in similar ecosystems, sharing similar livelihood systems, trans-clan and transboundary trade networks, and trans-boundary migratory patterns. Unlike pre-colonial times when communities freely moved with their herds, the creation of the colonial boundary has divided local people and restricted their mobility. This study has examined the effects of international boundary making on cross-border environmental resource use in the Ethiopia-Kenya border. The study employed a qualitative approach to study the issue in focus. Key informant interviews, in-depth interviews and focus group discussions were employed to collect data. The findings suggest that the boundaries between Ethiopia-Kenya constrain pastoral mobility beyond borders, access to cross-border environmental resource use and livelihoods. Interestingly, the ethnic kinship relationship and indigenous institutions have facilitated the Moyale pastoralists' mobility to get access to environmental resource use, resource use related conflict management and supporting pastoral livelihoods. As a way forward, this study states cooperative relations among the neighboring states, territorial communities and all concerned stakeholders must be promoted and strengthened, as well as investment made in pastoral livelihoods that allows mobility of pastoral communities across the borders of member states. In the case of Ethiopia and Kenya, this implies putting into action the Niamey Convention (2014) on African Union cross-border cooperation and the IGAD transhumance protocol (2021) to enhance free and safe pastoral mobility with livestock across the border, and all stakeholders in transboundary situations should strive to engage in joint rangeland management and cooperate to deter rangeland degradation are some among the stated ones.

Smart Urban Solutions Resulting from Flood Risk Assessment

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Based on the rainfall-runoff model of the territory in three scenarios, the flood threat in the urban environment is solved. The scenario modelling procedure using FLO-2D and HEC-RAS software is intended for risk prediction resulting from climate change and the design of smart solutions in the urban environment. The procedure concluded with the proposal of measures to reduce the size of the flood threat in the city and the flood risk is intended to increase of city resilience and sustainability of the urban area in terms of new modes of planning and innovative spatial planning.

Integrating Remote Sensing and In-Hive Monitoring to Understand Absconding in African Honey Bees (Apis Mellifera Scutellata) in Kenya

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In Kenya, the East African lowland honey bee (Apis mellifera scutellata) undertakes a seasonal migration wherein the entire colony absconds with any food stores, but little is known about the factors determining which colonies abscond and when. It has been hypothesized that colonies abscond from locations where there are few flowering plants, as a result of seasonal changes or land use conditions. However, it has previously not been possible to obtain detailed temporal data on colony absconding patterns across a diversity of land use conditions and different microclimates. We used in-hive monitoring devices including scales and temperature sensors to track absconding on a daily level, as well as monthly apiary-level observations to track absconding rates of colonies across 8 sites in the Kenyan counties of Kakamega, Kitui, Makueni, Murang'a, Nakuru and Taita-Taveta. We compared absconding rates with weather and landscape data sourced from satellite remote sensing data as well as initial colony weight measurements and pollen diversity metrics from bee bread samples. Precipitation values were sourced from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) daily values, and an unsupervised landcover classification was generated from composites of Sentinel 2-a imagery. The results of this study may have

implications for honey bee research and development projects in Kenya, as well as for beekeepers and farmers whose annual activities are linked with the seasonal absconding of honey bees.

Towards Quantification of Cooling Effect of Trees in Urban Environment in the Warming World

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Historical urban parks join cultural and natural heritage and represent important objects from the viewpoint of biocultural diversity. Almost every city on earth is warmer than the surrounding area by 1–4 °C and acts as a "Urban heat island". The effect of the thermal island of cities lies primarily on the high portion of the built-up area on a small proportion of vegetation. Asphalt, buildings and other dark surfaces absorb solar radiation, what causes that these surfaces are about 10–20 °C warmer than the surroundings and subsequently released the heat to the atmosphere. In this contribution, we present the methodology how to quantify cooling effect of trees in the historical parks by using sap flow measurements. Flow of sap in the tree stem can be measured by instrumental methods which are able to measure sap flow dynamic in high temporal resolutions. In this way, the detailed data about quantity of water transpired by trees can be obtained. This quantitative sap flow data can be recalculated to amount of energy used for conversion of water state from liquid to gas. The energy required to convert liquid to gas water status is referred as specific evaporative heat. The amount of 2450 kJ of energy is needed to evaporate one kilogram of water at 20 °C. This energy is consumed from the incidental solar radiation and thus cannot participate in heating the surface and then radiating the heat to the surroundings. The above-described methodology can serve as a tool for assessment of environmental benefits of historical parks within the new phenomenon of heat islands in the urban environment. The contribution was supported by project Biocultural Diversity – joining of cultural and natural heritage in historical urban areas (no. DH23P03OVV002) within the NAKI III Program founded by the Czech Ministry of Culture.

Biomass and Carbon Stock Estimations in Cashew-Based Agroforestry System, Cashew-Based Monoculture System and Forest for Climate Mitigation in the North, Côte d'Ivoire.

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Carbon stock estimates have often been used to mitigate climate change on a large scale, improve human well-being and reduce greenhouse gases. This study is a comparison of carbon stock estimates in a cashew-based agroforestry system, a cashew-based

monoculture system and a forest. As a case study across the Poro and Hambol regions, in northern Côte d'Ivoire, a survey was conducted among 150 cashew farmers and their cashew plantation characteristics were assessed. Ecological data were collected through measurement of height and DBH of each tree in 20 plots each of 50m×50m per system over a total area of 15 ha. Data was subjected to Hierarchical ascending classification (HAC), Principal Component Analysis (PCA), and the Man Kendall test. Results showed that the Above-ground Biomass, below- ground Biomass, carbon stock and carbon dioxide in clear forest were 61.93 t /ha; 22.91 t /ha; 39.88 t C/haand146.36 t CO_2/ha, respectively. This is higher than values from the cashew-based agroforestry system (58.33 t /ha; 21.58 t /ha; 37.56 t C/ha and 137.86t CO_2/ha, respectively) and cashew-based monoculture system (37.76 t /ha; 13.97 t/ha, 24.68 t C/ha and 90.57 t CO_2/ha, respectively). The carbon stock in the cashew-based agroforestry system is comparatively closer to that of the clear forest system than in the cashew-based monoculture system, and thus represents a very good choice for mitigating climate change while cultivating cashew. The analysis of the observed climate indices such as temperature and precipitation reveal that cashew producers have a more realistic view of climate change. These changes are mostly related to the decrease in the annual total precipitation (PRCPTOT), which is linked to changes in CDD/CWD, Tn10P/Tn90P, and Tx10P/Tx90P. The stakeholders' efforts must also be focused on integrating climate change into the sustainable production of perennial crops like cashew, as well as making commitments to transform most cashew-based monocultures to diverse agroforestry systems in Côte d'Ivoire.

Assessment of Meteorological and Streamflow Drought Characteristics in Agago Sub-Catchment, Northern Uganda

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A sound understanding of the characteristics and interactions between meteorological and streamflow drought patterns is vital for drought early warning. This study assessed meteorological and streamflow drought characteristics in Agago sub-catchment, Northern Uganda. The study specifically: i) assessed the spatial-temporal characteristics of meteorological drought; ii) assessed the characteristics of streamflow drought, and iii) assessed the time-lags between meteorological and streamflow drought events in Agago sub-catchment. Archived climate and streamflow data obtained from Princeton University datasets and Directorate of Water Resource Management; Uganda were used. A suite of analytical approaches including non-parametric tests, descriptive statistics and spatial interpolation were utilized to determine the significance of spatial-temporal trend of meteorological drought events and streamflow drought events. A correlation analysis was conducted to determine the relationship between the occurrence of meteorological and streamflow drought. Results of the study revealed that meteorological and streamflow drought mutually occurred in the same

years and meteorological drought events were mainly experienced in Abaneka area compared to the other areas in the sub-catchment. The probability of meteorological drought occurrence for a 3 months' duration was 79.7% at all the four stations and these drought episodes were mainly observed from December to February. The most severe meteorological drought years recorded were 1983, 1998-1999, 2002, 2004, 2006-2007 2011-2012 and 2016. However, streamflow drought events were mainly experienced in December-June and the most severe streamflow drought years were recorded in 1987, 1991, 1998, 2002, 2004, 2007, 2012 and 2016. There was a significant positive relationship between meteorological drought (Standardized Precipitation Index (SPI) and streamflow drought (Streamflow Drought Index (SDI) in the sub-catchment. This relationship was however most pronounced in the SPI-12/SDI-12 compared to SPI-3/SDI-3 and SPI-6/SDI-6. Cross-correlation analysis indicated that SPI and SDI at 3 and 6 months timescale have a zero month time-lag whereas SPI and SDI at 12-month timescale reached a maximum correlation coefficient at one-month (30 days) timelag indicating that occurrence of streamflow drought in a catchment is delayed by at least one month after meteorological drought has occurred. Therefore, a one-month lag time should be used when considering drought early warning and management options for drought hazard in the sub-catchment.

Policy and Management Effectiveness of the Gola Forest National Park (Liberia) and Its Significance for the Livelihood of Park Fringe Communities

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The Gola Forest National Park (GFNP) in Liberia is a transboundary protected area between Liberia and Sierra Leone covering an area of 88,000 hectares and several big watercourses. However, since its delimitation and protection in 2016 by the government of Liberia, few studies have evaluated the effectiveness of its management policy and especially its impact on the livelihoods of the local population. Also, no study has been conducted on the floristic diversity of the park. This study aimed at assessing the management effectiveness of the Gola Forest National Park and its significance for the livelihood of forest fringe communities. Specifically, it aimed to: (i) assess the current management plan of GFNP; (ii) determine the impact of the park's management on the livelihoods of the surrounding populations; (iii) assess gender roles and responsibilities in the management of the park; and (iv) evaluate the impact of the park's management effectiveness on its biodiversity. This interdisciplinary research work resulted in both quantitative (ecological data) and qualitative (socio-economic surveys) data collection in the GFNP and community forests, as well as with policymakers and local populations; using individual household surveys, focus group discussions in ten forest fringe communities as well as stakeholders' discussions. Three out of the plants species are on IUCN Red List of threatened species: *Cassia fikifiki, Garcinia cola* and *Eremosa dransfieldi*. Additionally, there was more species richness in the park than in community

forests but the viability of the species is compromised due to overexploited by the populations. A participative management plan and the development of good community-based measures are prerequisites to mitigate the pressures on the park and to increase the influence of local communities in the decision-making process for optimal management of the park.

Green and Blue Infrastructure Resource Centre: Using Research-Based Geospatial Methods and Tools to Support Ecological Continuity Policy

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The Green and Blue Infrastructure (GBI) is a national policy aimed at integrating biodiversity into land-use planning decisions by focusing on the preservation and restoration of ecological continuities in Europe. Its implementation in France, is based on the involvement of stakeholders at all levels, from national to local, including regional level, river basins and inter-municipal levels. In order to support professionals and stakeholders in charge of implementing the GBI, the government at the National level supports a "Resource Centre" dedicated to the GBI. This Centre is composed of several structures and different stakeholders that combine their skills for the deployment of the GBI policy implementation: the French Biodiversity Office (OFB) (coordination), the National Research Institute for Agriculture, Food and the Environment (INRAE), the Natural Heritage Joint Service Unit (Patrinat) and the Centre for Studies and Expertise on Risks, the Environment, Mobility and Development (Cerema). Through a participatory approach working with different actors of the GBI, the Centre proposes different actions: Support and Produce technical, methodological and scientific resources; Disseminate news; Gathering and promoting the exchange of different GBI experiences and Facilitates exchanges among stakeholders and promotes capacity building. In this role of supporting public policies, INRAE develops geospatial methods and tools to facilitate the modelling and mapping of ecological continuities. In particular, it produces open source QGIS plugins such as *Biodispersal*, *MitiConnect* or *LightPollutionToolbox* to facilitate the application of these methods by design offices, communities, government services or students for example. This resource centre approach makes it possible to transfer research methods to civil society as efficiently as possible.

Bamboo: Indigenous Knowledge, Innovation, and Livelihood in Southern Highlands of Tanzania

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Bamboo has the potential to be a climate-smart income generator for communities in bamboo-producing

countries. Its fast growth, environmental benefits, material properties, and versatile applications make it a valuable resource. However, bamboo has not been fully utilized in productive land uses, furniture, and construction industries, missing out on its substantial contribution to local community development. This study aimed to bridge the information gap by exploring indigenous knowledge, innovation, and utilization technologies in the Iringa, Njombe, and Mbeya regions of the Southern Highlands in Tanzania. Using systematic random sampling, data was collected through focus group discussions, household surveys, and key informant interviews. The findings from 317 responses showed that indigenous knowledge (42.27%) and personal technical skills (30.28%) were the primary sources of knowledge for product innovation. Local competitors (10.1%), mass media (6.31%), and the internet (4.42%) also played a role. Traditional bamboo enterprises gained skills, knowledge, and creativity through interactions with local competitors, mass media, and the internet. Tactics such as information exchange (80%), joint buying/selling (73.3%), experience sharing (73.3%), and group work (26.67%) facilitated the improvement and spread of innovation technologies. The study revealed the diverse uses of bamboo within the local communities. Bamboo was utilized for over 20 different purposes, including food (young shoots) and drinks (bamboo juice and ulanzi), basketry (hand baskets, winnowing baskets, hats), crafts (mats, rugs, fish trapping cages, utensils, decorative materials), house construction, furniture (chairs, beds, tables), medicine, and fuel. These indigenous technologies contribute to agricultural and environmental innovation, serving as nature-based solutions for sustainable food security and enhanced environmental conservation for both local and global communities.

Towards co -Existence: Are Mitigation Measures Effective and Easily Adopted?

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In Tanzania, Human Wildlife Conflict (HWC) has become a serious conservation issue because of the increased human population and corresponding demands on natural resources, the increasing human population strives to fulfil their basic needs at the expense of the fixed natural resource base, in turn diminishing wildlife habitats and increasing pressure at the human-wildlife interface (HWI). The common types of human-wildlife conflicts in Tanzania include human-elephant conflict (HEC), human-carnivore conflict (HCC), human-crocodile conflict and human-hippopotamus-conflict (HHC). HWC incidents reported to the Wildlife Division over the past five years from 2017/18 to 2021/22 indicated that the number of deaths caused by dangerous animals approximately doubled from 85 to 164, livestock depredation increased from 261 to 328, whereas incidences of permanent injury to people and crop damage measured by the size of acres cultivated kept on fluctuating from year to year (URT, 2022). Generally, HEC has significantly affected food security among households in Tanzania and that the amount of money spent by the Government for consolation

payments has increased from about 985 million shillings in 2019/20 to 1.2 billion shillings in 2021/22 (URT, 2022). This manuscript highlights few case studies, assess the socio-economic drivers of HEC incidences and use Maxent models for predicting possible future conflict hotspots. The results in this manuscript further detailed the existing non-lethal mitigation plans and their adoption rate.

MWARES: An ecosystem-based approach for landscape restoration

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Watersheds are increasingly under threat from degradation and over-exploitation of their natural resources. Deforestation and forest degradation, unsustainable farming practices, and an increasing population pressure led to an over-use of land for crops and livestock that are not well suited for such (intensive) use. Intensified land use has resulted in the gradual loss of biodiversity, but also in the diminution of the ability of these forest ecosystems to provide essential ecological services. When ecosystem processes and functions are drastically perturbed, communities suffer from a less resilient farming system, while biodiversity declines as a result of ecosystem degradation. To reverse this trend, landscape restoration is essential to conserve and restore the watershed's ecosystem services and establish resilient farming systems for sustainable livelihoods. The MWARES project focuses on the Manafwa watershed in Eastern Uganda, which originates from the Mount Elgon National Park and then flows through a densely populated area, providing all kinds of ecosystem services along the way. Mount Elgon is a national park straddling the border of Uganda and Kenya. The national park is preserved for its important nature values, endemic plant species, and some wildlife. However, increased population pressure leads to encroachment on the park by communities bordering the park. MWARES aims to make farming practices sustainable, replenish the soils, and taking preventive measures for soil protection such as planting trees and digging trenches to regulate run-off water. The project follows the 'landscape approach' (Sayer et al., 2013). The landscape approach gives due consideration to: (1) different stakeholders, sectors and scales in a landscape (2) adaptive and participatory management of change processes; and (3) social learning and capacity building. Important characteristics of this approach within the MWARES project are: adaptive management; resilience, in the group and landscape, working at multiple scales with a multistakeholder approach, participatory monitoring and in particular continuous learning and strengthening stakeholder capacity.

Keywords: Sustainable land management, landscape restoration, PIP, landscape approach, ecosystems, stakeholders

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