TERRA ENVISION

7-10 September 2026
Trier, Germany



TERRAenVISION 2026

Nature-based Solutions to Facilitate the Transitions for living within the Planetary Boundaries

Trier, Germany, 7-10 September 2026

Editors

Saskia Keesstra, Wageningen University & Research

Manuel Seeger, University of Trier

Margot de Cleen, Rijkswaterstaat, Ministry of Infrastructure and Water Management

Ioannis Daliakopoulos, Hellenic Mediterranean University

Artemi Cerdà, University of Valencia

Publication

Hellenic Mediterranean University, University Research and Innovation Center, Institute of Energy, Environment and Climate Change
Estavromenos, 71 410 Heraklion, Greece

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TERRAenVISION 2026 in numbers

87 abstracts co-authored by 282 authors from 37 countries are published in this book of abstracts of TERRAenVISION 2026.



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Netherlands 21
Italy 16
New Zealand 15
France 10
Czech Republic 9
Portugal 8
United States 7
United Kingdom 7
Luxembourg 7
Belgium 6
China 6
Greece 6
Brazil 6
Nigeria 6
Sweden 5
Iran 5
Hungary 4
Cyprus 3
Colombia 3
Poland 3
Canada 3
Turkey 3
Pakistan 3
Ukraine 2
Austria 2
Sri Lanka 2
India 1
South Africa 1
Switzerland 1
Ethiopia 1
Indonesia 1
Somalia 1
Ireland 1
Denmark 1
Saudi Arabia 1

Organisers

Manuel Seeger

Senior Lecturer & Researcher in
Physical Geography, University of Trier



ResearchGate Google Scholar LinkedIn

Dr. Manuel Seeger is an Akademischer Oberrat at the Chair of Physical Geography, University of Trier. He studied Geoecology at the University of Karlsruhe (TH) and earned his PhD (Dr. rer. nat.) in Geography from the University of Freiburg in 2001. His academic career includes positions as a scientific assistant at the University of Trier (2002–2008) and as a university lecturer at Wageningen University in the Netherlands (2009–2011), before returning to Trier, where he has served since 2012, becoming Oberrat in 2016. His research focuses on Earth surface processes, particularly runoff generation and soil erosion across scales and landscapes. He has extensive field experience in both Mediterranean and temperate regions, working on topics ranging from semi-arid steppes to vineyard slopes. Dr. Seeger is also actively engaged in teaching, offering seminars, field excursions, and thesis supervision for BSc and MSc students. His expertise combines field-based process research, hydrology, geomorphology, and methodological innovation in observing and quantifying landscape dynamics.

Thomas Iserloh

Staff Member, Nature Conservation and Water Authority, District Administration Trier-Saarburg



ResearchGate Google Scholar LinkedIn

Dr. Thomas Iserloh is a specialist in landscape management, nature conservation, and river maintenance in the District of Trier-Saarburg, working within the district's water and nature conservation authorities. He also serves as an external lecturer and associate researcher in Physical Geography at Trier University.

He holds a degree in Environmental Science (Diplom-Umweltwissenschaftler) and a doctoral degree (Dr. rer. nat.). His expertise covers geomorphological, hydrological, and soil-physical processes, as well as human–environment interactions and the enforcement of water, soil, and environmental law. In the Trier-Saarburg District, his work includes nature-based flood protection, river development and maintenance, municipal land management, and soil conservation.

Dr. Iserloh's research combines field and laboratory methods to investigate soil detachment, transport processes, and the effects of rainfall and wind on erosion dynamics. He is also recognized for his contributions to developing portable rainfall and wind simulators used in experimental geomorphology.

In his teaching, he covers a broad range of topics in physical geography, including fluvial, glacial, periglacial, aeolian, karst, and coastal geomorphology, alongside applied field and laboratory methods. His numerous scientific publications and collaborative research projects reflect his dedication to understanding and quantifying soil erosion and land degradation processes across diverse landscapes.

Johannes Ries

Professor of Physical Geographer,
University of Trier



ResearchGate LinkedIn

Prof. Dr. Johannes B. Ries is Professor and Head of the Chair of Physical Geography at the University of Trier. His research focuses on geomorphology and Earth surface dynamics, with a particular emphasis on experimental approaches to soil erosion, runoff generation, and the use of aerial photography and unmanned aerial systems (UAS) for landscape process analysis. He has conducted extensive fieldwork in Mediterranean regions, West Africa, and South Asia, studying how climate, land use, and topography interact to shape surface processes. In his teaching and research, Prof. Ries integrates field experiments, such as rainfall simulations and erosion studies on vineyard slopes, with modern remote sensing techniques to quantify and model environmental change. He also plays an active role in academic administration, chairing the Departmental Committee for Studies and Teaching. His publication record includes more than 250 scientific papers and collaborative works in geomorphology, hydrology, and environmental science, reflecting his long-standing contribution to the understanding of landscape evolution and process-based geomorphological research.

Artemi Cerda

Professor in Physical Geography,
University of Valencia, Spain



ResearchGate Google Scholar X

Professor Artemi Cerdà completed his PhD on the infiltration capacity of Mediterranean soils between 1989 and 1993. His postdoctoral research in the Netherlands, Israel, Bolivia and Extremadura addressed soil hydrology, the impact of climate on geomorphological processes, and the effects of fire and agriculture on soils. As a researcher at the Desertification Research Centre and the Pyrenean Institute of Ecology from 1998 to 2002, he studied the interactions between seeds, plants and erosion, as well as land management and soil erosion in the Pyrenees, work that broadened his view of soil erosion accelerated by human activity. He joined the University of Valencia as Associate Professor in 2002 and has been Full Professor there since 2009. He founded the Soil Erosion and Degradation Research Group and the Soil Erosion Research Stations of Montesa and Serra de Enguera. His research focuses on the effects of agriculture, forest fires and roads on soil erosion, and on finding sustainable management practices for agricultural and forest soils.

Margot de Cleen

Senior Advisor, Soil and Water Ministry of Infrastructure and Water Management, The Netherlands



ResearchGate

Margot de Cleen works for the executive agency Rijkswaterstaat, of the Dutch Ministry of Infrastructure and Water Management as senior advisor Soil and Water. She works on the science policy interface and thus has acted as project manager for the Cost Benefit Analyses on the Dutch Soil Remediation Operation and the Dutch Knowledge agenda on soil and subsurface. She was involved in the realization of the first Soil Covenant. She is member of the Expert group Soils of the European Commission and is active in the Common Forum network for contaminated sites and in the Common Forum working group “Soil as a resource”. In the Netherlands she is member of the core group of the societal initiative on conscious use of soil where she is active in awareness raising and capacity building. She initiated the TerrAgenda conferences. and is involved in the start of the dialogue to implement the SDG 15.3 Land Degradation Neutrality in the Netherlands.
As an advisor on soil and water policy at the Dutch Ministry of Infrastructure and Water Management at the Directory Environment of Rijkswaterstaat she promotes sustainable use of land and soil as essential for achieving the SDGs (the UN sustainable development goals). She has contributed to a booklet on land stewardship: Investing in the Natural, Social and Economic Capital of Industrial Land, a joint effort of the policy network Common Forum and industry network Nicole.
Margot has studied at the Wageningen University and Research Centre with a specialization in soil hygiene. She started her working career at the Dutch Commission on Environmental Impact Assessment. She worked at the Dutch Research Institutes Deltares and RIVM on concepts for risk based soil remediation and monitoring before entering the realms of policy making at the Ministry of Infrastructure and Water Management.

Saskia Keesstra

Senior researcher, Wageningen Environmental Research, Netherlands



ResearchGate Google Scholar LinkedIn

Senior researcher at Soil, Water and Land use Team. She has 16 years of experience in Sustainable Land Use research (160 ISI research and opinion papers; H index/citations: in Google Scholar = 52/8,776, in Scopus = 49/7,122; since 2019 part of the highly cited list of Clarivate (top 0.1% of citations in the field).

Her main aim is to find scientific solutions for societal issues; process knowledge for sustainable development. Her research focusses to understand the processes that determine sustainable land and water use. Process knowledge enables explanation of the impact of natural and human drivers on the catchment systems and which consequences these drivers have for water and sediment connectivity. Improved understanding of the catchment sediment and water dynamics will empower sustainable land and river management to design sustainable management strategies in agriculture and nature conservation. This will help to mitigate soil threats like erosion and off-side water and sediment accumulation with the help of nature's forces. This knowledge is necessary to be able to design sustainable management strategies in agriculture and nature conservation. In addition, she focusses on interaction with stakeholders, from farmers to policy makers, which is essential to come to usable, acceptable tools for sustainable land management and achieve the Sustainable Development Goals.

Ioannis Daliakopoulos

Assistant Professor, Hellenic Mediterranean University, Greece



ResearchGate Google Scholar LinkedIn

Dr. Ioannis Daliakopoulos is an Assistant Professor at the Department of Agriculture at the Hellenic Mediterranean University, Greece. His research interests include extreme weather events and climate change impacts in the urban and rural environment. While always involved in field studies, he specializes in the application of data mining and forecasting tools using of machine learning and optimization algorithms to analyze spatio-temporal datasets and stochastic processes.

Keynote speakers

Bertram de Rooij

Landscape architect, Wageningen University & Research



ResearchGate Google Scholar LinkedIn

Working together on vibrant and resilient landscapes. Landscapes that evolve and landscapes that transform without losing intrinsic values and their natural basis. Landscapes that breath quality because they are loved and useful. Landscapes that reflect society and its needs. Landscapes that connect.
In more than 20 years of experience as a landscape architect, I have worked on a broad variety of assignments, in numerous areas and themes, in the Netherlands and abroad.
Considering that almost all societal challenges come together in the same spatial context, the landscape, my focus is on creating enabling environments at different scales together with all involved. That is why I specialized in creating enabling environments that offer opportunities and bring together the challenges, at different scales and always togther with all stakeholders.
I work on rooted and nature based solutions, climate adaptation and risk reduction, sustainable and resilient food systems and migration. Always from and with a spatial perspective.
The heart of my approach is to connect, to innovate and to inspire. By bringing people, knowledge, needs and desires together. Creating common understanding, building bridges and visualizing envisioned futures, via clear storylines and appealing visualisation.
With an open attitude, humor and passion. Creativity, flexibility, promptness and thoroughness, are words that characterise me well. I also bring in a strong sense for political and social relations, new developments and phenomena. I value direct actions and follow-up; hands-on by nature. From vision to implementation.
A shared, inspiring, activating story with a powerful spatial perspective, in which the natural system and the societal challenges come together and long term ambitions are connected to short term action perspectives; that will make the difference!
As such, we work together on a healthy, sustainable and resilient living environment, now and in the future!

Paul van Dijk

Physical Geographer, Chambre Régionale d’Agriculture Grand Est



ResearchGate LinkedIn

Paul van Dijk is a physical geographer specializing in soil erosion, sediment transport, and water quality in agricultural landscapes. After completing his PhD at the University of Amsterdam (2001) on the impact of climate change on erosion-driven sediment supply to rivers in the Rhine basin, he worked as a Marie Curie postdoctoral fellow at the University of Strasbourg on regional-scale erosion modelling.

He has since contributed to applied research and territorial projects in the Rhine Rift Valley, including modelling nitrate leaching and developing groundwater quality indicators within INTERREG programmes. Since 2018, he has been working at the Chambre Régionale d’Agriculture Grand Est (CRAGE), focusing on territorial modelling using the MAELIA platform (INRAE).

His current work addresses soil erosion and muddy flood risks at the small catchment scale, with a strong emphasis on evaluating the effectiveness of mitigation measures such as conservation tillage and Nature-Based Solutions. Throughout his career, Paul van Dijk has combined fundamental research with applied, stakeholder-oriented projects, contributing to improved understanding and management of soil and water systems in agricultural landscapes.

John Reid

Professor of Environmental Systems and Indigenous Knowledge, University of Canterbury, New Zealand



ResearchGate LinkedIn

Professor John Reid is Professor of Environmental Systems and Indigenous Knowledge at the Ngāi Tahu Research Centre, University of Canterbury, New Zealand. His research explores how Indigenous knowledge systems can inform environmental governance, sustainability, and the development of innovative technologies for managing natural resources. He leads research spanning environmental digital twins, Earth observation, artificial intelligence, Indigenous data sovereignty, climate adaptation, and nature-based solutions, working closely with Māori communities, government agencies, primary industries, and international partners. Professor Reid also serves as a director and advisor across a range of research organisations, government agencies, and private sector companies, helping translate research into policy and practice. He is an Associate Editor of the *Journal of the Royal Society of New Zealand*. His work seeks to weave Indigenous knowledge with science to develop more equitable, resilient, and regenerative approaches to environmental management.

Gera van Os

Professor of Sustainable Soil Management, Aeres University of Applied Sciences



LinkedIn

In the International Year of Soils, 2018, Gera van Os was appointed professor of Sustainable Soil Management. Her personal ambition is to provide students with sufficient background knowledge, in order to adopt a researching and critical mind regarding the information and challenges that they face in the field. Besides her substantive expertise, she has extensive experience in passing on information from research to education. She is a skilled adviser on innovation issues and collaboration forms between research, education and entrepreneurs.

Gera completed two study programmes: Biology at Amsterdam University and Plant Pathology at Wageningen UR. She did her doctoral research at Leiden University at the department of Microbial Ecology. Her subject was soil resistance to Pythium root rot in flower bulb breeding. She has been a scientific researcher at Wageningen Plant Research for more than 25 years.in the field of plant and soil health.

Bob Klein Lankhorst

Co-Founder & Chief Soil Officer,
Antonie



LinkedIn

Bob Klein Lankhorst is a pioneering soil specialist and the Co-Founder & Chief Soil Officer of Antonie, where AI-driven soil intelligence is being developed. Combining deep expertise in soil science, functional biodiversity, and ecosystem services, he is redefining how soil health is measured, monitored, and understood worldwide.

As an entrepreneur and as convenor of European standardisation body CEN/TC 444/WG8 “Assessment”, Bob plays an active role in shaping new national and international guidelines for soil health assessment. His work at Antonie focuses on building the world’s most advanced AI-powered soil biodiversity insights, with that empowering farmers, researchers, and landowners with precise, data-driven understanding of their soils.

Bob’s mission is clear: to establish Antonie as the global standard for measuring functional biodiversity and ecosystem services. Through this work, he aims to support better soil-health decisions, restore biodiversity, and contribute to improved human and environmental well-being on Earth.

Bob began his professional journey in soils with his company Bodemliefde (in Dutch: “for the love of soil”). What started as a soil consultancy has since evolved into a thriving community-supported agriculture (CSA) non-chemical garden, reflecting his lifelong commitment to living soils and sustainable land stewardship.

Fransje Hooijmeijer

Associate Professor Environmental Technology & Design, TU Delft



ResearchGate Google Scholar LinkedIn

Fransje Hooimeijer specialises in system integration of technical conditions in urban design and interdisciplinary design. She is trained as a designer at the Willem de Kooning Academy, as a researcher at Erasmus University, and after having been an independent researcher for a number of years, she carried out a PhD research at TU Delft. In her research and teaching at Delft University of Technology, she takes the perspective of the city as a technical reconstruction of the landscape. She is passionate to understand how nature can be brought closer to people with concepts such as ecosystem participation and reversed engineering with nature as the foundation for a climate-resilient, natural city. She is involved in national and international practice and research projects, is editor of the Journal of Delta Urbanism, has contributed to several books and has published in urban planning, technical and scientific journals. Within the TU Delft she contributes to the organization in the capacity of section and research group lead, coordinator of the interfaculty Delta Futures Lab and theme lead in Port City Futures Institute.

Birgit Peters

Professor of Public Law, University of Trier



ResearchGate Google Scholar LinkedIn

Prof. Dr. Birgit Peters is Professor of Public Law, with a focus on International Law and European Law, at the University of Trier. Her research concentrates on international and European environmental law, the internationalisation and Europeanisation of administrative law, and the institutional protection of human rights at the international and European level. She studied law and holds both doctoral and postgraduate qualifications, including an LL.M. in international law. Before joining the University of Trier, she worked as a legal scholar and practitioner, developing expertise in public international law and environmental governance. Prof. Peters is actively involved in international legal research networks and contributes to policy discussions on biodiversity conservation, sustainability, and the intersection between human rights and environmental protection. Her teaching covers public international law, European Union law, environmental protection law, participatory rights in administrative procedures, and global governance. She has published extensively on topics such as the right to a healthy environment and the legal dimensions of global environmental challenges.

Carla Sofia Ferreira

Polytechnic University of Coimbra, Portugal and Chair of IWRA Task Force LAND4FLOOD



ResearchGate Google Scholar

Carla Ferreira is a postdoctoral researcher at Stockholm University, since 2020. She works on different land degradation problems, focusing on the impact of anthropogenic activities on soil properties and water resources, and the use of nature-based solutions to mitigate the impacts.

She has a European doctoral degree in Environmental Science and Engineering, since 2015. She has worked as a researcher for the Polytechnic Institute of Coimbra, Portugal, and Swansea University, UK. She is the Research Area Leader of Center for Natural Resources, Environment and Society (CERNAS) for Environment and Society. She develops research for the Navarino Environmental Observatory (NEO). She has been working on several national and international research projects, working on land degradation driven by urbanization, intensive agriculture management practices and wildfires.

She has been actively involved in the editorial board of international scientific journals, in the organization of national and international scientific events, and in the Management Committee of the COST Action Land4Flood – Natural flood retention on private land (CA16209). She is the main editor of the book entitled “Nature-Based Solutions for Flood Mitigation: Environmental and Socio-Economic Aspects”, currently in print by Springer Nature.

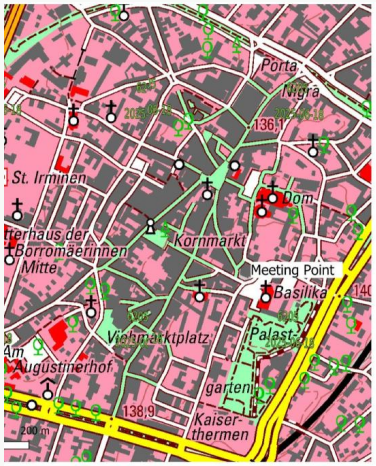
PROGRAMME AT A GLANCE

Nature-based Solutions to facilitate the transition for living within the Planetary Boundaries

6-10 September 2026 | Trier, Germany | University Trier - Campus 2

TERRAenVISION 2026
www.terraenvision.eu

SUNDAY 6 SEP



15:00-17:00

NBS CITY WALK

Meeting at Basilika Square.
Exploring Nature-based Solutions in a 2000-year-old city.

Detailed program

SEDER
soil erosion and degradation research group

MONDAY 7 SEP

08:00-09:00
Registration

08:30-09:00 HS11
Opening

09:00-10:30 HS11
AGRICULTURE & NATURE

Gera van Os
John Reid (NZ)
Discussion

10,30-11,00
Coffee break

11:00-12:30
PARALLEL SESSIONS

AN1 Land Degradation & Restoration HS11
MET1 Integrated Methodologies HZ203

12,30-14,00
Lunch break

14:00-15:30 HS11
METHODOLOGIES

Bob Klein Lankhorst
Paul van Dijk
Discussion

15:30-17:00
PARALLEL SESSIONS

AN4 NBS in Agriculture HS11
MET7 Implementation & Monitoring HZ203

17:00-18:30
POSTER SESSION

Drinks & snacks - Foyer HZ

UNIVERSITÄT TRIER

TUESDAY 8 SEP

08:00-09:00
Registration

09:00-10:30 HS11
URBAN & INDUSTRIAL AREAS

Fransje Hooijmeijer
Ivonne Weichhold
Discussion

10,30-11,00
Coffee break

11:00-12:30
PARALLEL SESSIONS

UR2 Greening Cities HS11
SO1 More than Green HZ203

12,30-14,00
Lunch break

14:00-15:30 HS11
SCIENCE BROKERS

Birgit Peters
Feras Youssef
Discussion

15:30-17:00
PARALLEL / WORKSHOP

UR4 Phytomanagement HS11
SO5 Social Innovation HZ203
MET6: Tracking the ecological value (panel) HZ202

17:00-18:30
POSTER SESSION

Refreshments - Foyer HZ

20:00
CONFERENCE DINNER

Weinwirtschaft Friedrich-Wilhelm

WEDNESDAY 9 SEP

08:00-09:00
Registration

09:00-10:30 HS11
NATURAL HAZARDS Fire, floods & droughts

Bertram de Rooij
Carla Ferreira
Discussion

10,30-11,00
Coffee break

11:00-12:30
PARALLEL SESSIONS

UR3 Cross-scale Urban NBS HS11
NH3 Natural Hazard Mitigation HZ203

12,30-14,00
Lunch break

14:00-15:30
PANEL / WORKSHOP

AN6 Sustainable Terroir HS11
SO4 Circular Land & Soil Management HZ203

15:30-16:15 HS11
CLOSING SESSION

Implementation opportunities & barriers of NBS
Where do we go next? TERRAenVISION 7

TERRA ENVISION

THURSDAY 10 SEP

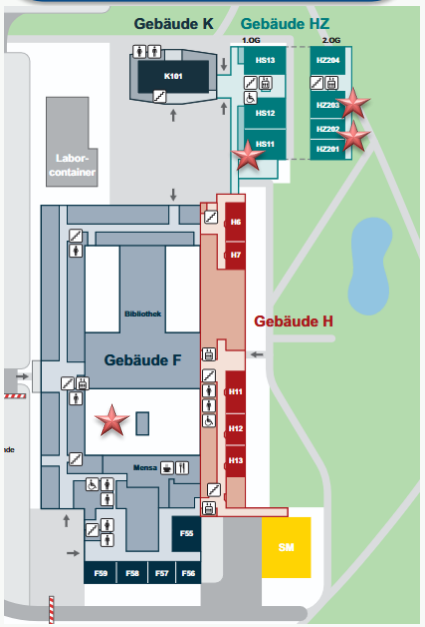


09:00-16:00

CONFERENCE EXCURSION

River restoration with NBS and steep-slope vineyards in the Saar valley.
Visit to Weingut winery and picnic-style lunch.

MEETING POINT - CAMPUS 2 PARKING LOT



Venue

TERRAenVISION 2026 takes place at **Campus II of Trier University**, Behringstraße 21, 54296 Trier, Germany. Plenary and parallel sessions are held in lecture hall HS11 and room HZ203 of building HZ, registration and posters in the HZ foyer, and lunch is served at Mensa Petrisberg.

Bus stops: Kürenz, Campus 2 (lines 4 and 14) or Kürenz, Behringstr. (line 88, after 18:00). Public transport planning in and around Trier: www.vrt-info.de.

Trier University (Universität Trier) was founded in 1473. Closed in 1798 by order of the then French administration in Trier, it was re-established in 1970 after a hiatus of some 172 years. The campus is located on the Tarforst heights, an urban district on the outskirts of the city, and the university has six faculties.



Map data © Google.

Conference Excursion

On 10 September 2026 the conference excursion went to the Saar valley. In the morning the group visited a river restoration on the Leuk near Saarburg, where obstacles and partially permeable dams built only from trees and rock fragments found on site let the river form pools and riffles and reach its floodplain again. The excursion continued to the ecologically managed steep-slope vineyards of Weingut Dr. Frey, where soil and vegetation management, such as aromatic plants under the vines, and fungus-resistant grape varieties are being tested, and ended with a picnic lunch at the winery.



River restoration on the Leuk



River restoration on the Leuk



Steep-slope vineyards in the Saar valley



Weingut Dr. Frey



Weingut Dr. Frey



Steep-slope vineyards in the Saar valley



Weingut Dr. Frey



Weingut Dr. Frey

Photos: Artemi Cerdà.

Day Excursion to the Ahr Valley

Reconstruction after the 2021 flood disaster

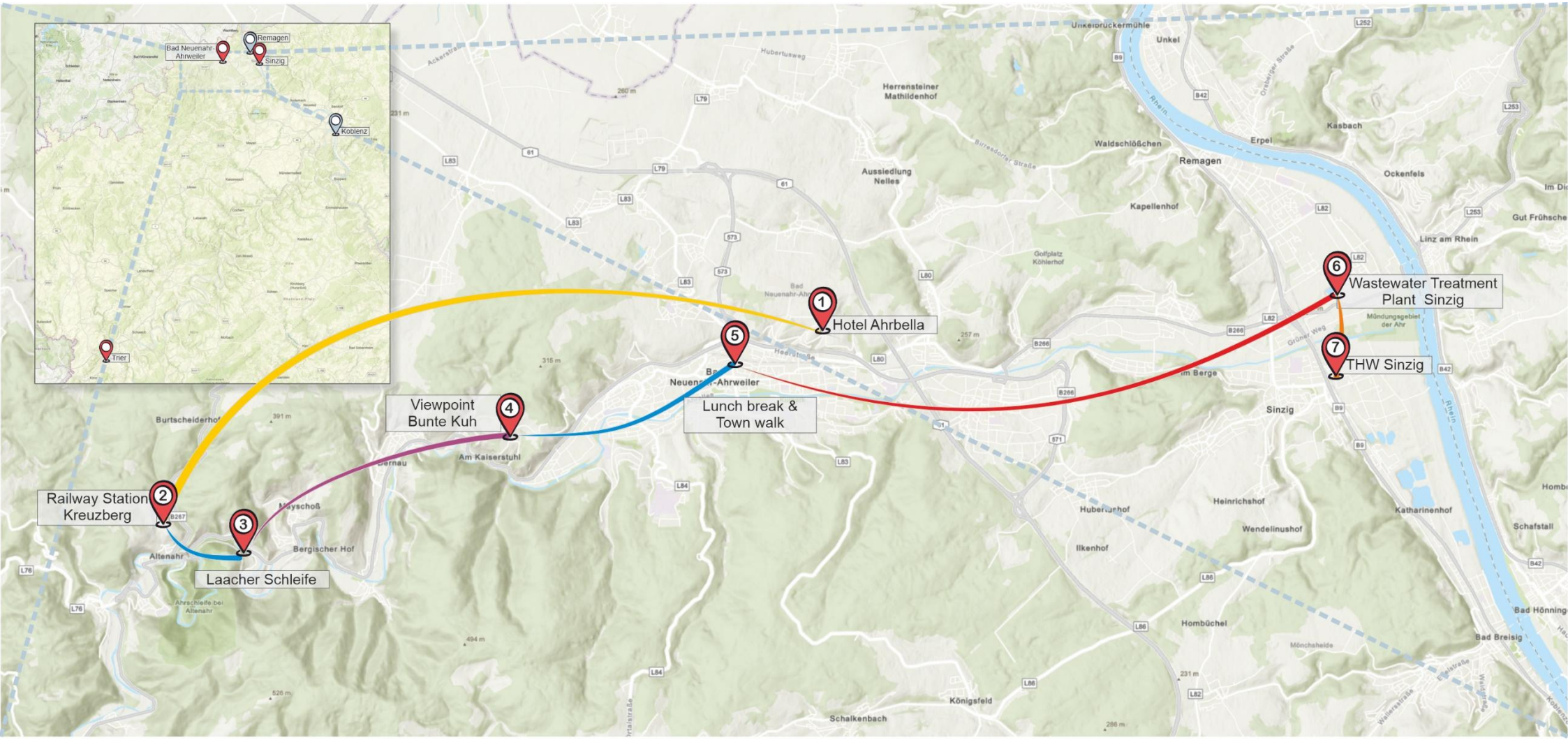
Meeting point: Hotel Ahrbella, Bad Neuenahr • Start: 08:30 a.m. • End: approx. 09:00 p.m.

🚌 **Transfer:** Transfers between all excursion stops are kindly organised by the THW Local Branch Sinzig using their own vehicles.

PROGRAMME

08:30 a.m.	**Hotel Ahrbella, Bad Neuenahr** Meeting point at the hotel car park *(Hauptstraße 45, 53474 Bad Neuenahr-Ahrweiler)*
09:00 a.m.	**Kreuzberg Railway Station (Altenahr)** Guided tour of the historic railway station
10:30 a.m.	**Mayschoß – Laacher Schleife** Visit to the newly constructed railway line
11:30 a.m.	**Walportzheim – Bunte Kuh** Visit to the viewpoint
01:00 p.m.	**Bad Neuenahr-Ahrweiler** Lunch break *(Restaurant to be announced)*
02:00 p.m.	**Bad Neuenahr-Ahrweiler** Town walk focusing on reconstruction efforts
03:30 p.m.	**Sinzig Wastewater Treatment Plant** Guided tour of the treatment plant
05:00 p.m.	**THW Local Branch Sinzig** Presentation on the 2021 flood response, introduction to the local branch, and joint barbecue
09:00 p.m.	**Return Journey** End of the excursion and return to hotels

Note: Programme subject to change.



Personal transfer from Trier (TERRAenVISION Conference 2026) **to Bad Neuenahr-Ahrweiler:**

By car: *Trier → A1 → A48 → A61 → Bad Neuenahr-Ahrweiler*	approx. 1 hour 45 minutes
By train: from *Trier via Koblenz and Remagen to Bad Neuenahr-Ahrweiler*	approx. 3 hours

AN1: Land Degradation and Restoration. Problems and solutions

TERRAENVISION Conference Abstracts
TERRAENVISION-AN1-3583-Oral
Trier, Germany, 7-10 September 2026
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Drivers of Triple Direction (Environmental – Societal – Economic) for Enhanced Forecasting of Future Land Use/Land Cover Transformations: Reviewing the Clue-S Modelling Framework in Mediterranean Settings.

Dimitrios Koumoulidis[1,*], Ioannis Varvaris[1] and Diofantos Hadjimitsis[2]

[1]*Eratosthenes Centre of Excellence, Cyprus*
[2]*Department of Civil Engineering and Geomatics, Cyprus University of Technology, Cyprus*

Abstract

Precise and robust predictions of Land Use and Land Cover Change (LULCC) are fundamental for achieving sustainable land management, safeguarding ecosystem biodiversity, and ultimately adhering to national/regional policy frameworks. Remote sensing (RS) approaches for Land Use and Land Cover (LULC) mapping, have markedly upgraded our proficiency in understanding and analysing spatial and temporal land change patterns, especially in fragile ecosystems such as the Mediterranean Basin, characterized by complex interactions between human influences and climatic extremes. A wide spectrum of current research demonstrates that land use modifications are majorly determined by a mix of biophysical and anthropogenic determinants, such as topographical features, climatic variables, demographic trends, and proximity to urban areas. Nonetheless, the existing body of literature frequently emphasizes a confined selection of those determinant factors, rather than a pluralistic modelling prediction approach. Analyses that are spatially explicit in Mediterranean contexts demonstrate that historical alterations of LULC are driven by synergistic, non-linear interactions between biophysical constraints and socioeconomic influences. This complexity underscores the need for integrative, multi-dimensional modelling approaches capable of capturing multi-scale change dynamics. In this manuscript, emphasis is placed on the urban and peri-urban zones of Larnaca, Cyprus, as we review the contemporary literature on LULC modelling and critically analyse the extent to which the current applications of the Conversion of Land Use and its Effects at a Small regional extent (CLUE-S) model incorporate a range of determinant factors. Building on this review, the study explores the necessity of integrating additional environmental and sectoral datasets - beyond conventional topographic, climatic, and demographic variables - into future CLUE-S simulations. These include EU and national geospatial prediction datasets such as erosion probability, desertification risk, flood susceptibility, Aquifer Quality Index, and Soil Organic Carbon (SOC) density maps. The manuscript argues that incorporating such multidimensional determinants can substantially enhance model sensitivity to both natural constraints and anthropogenic pressures, leading to more robust and policy-relevant LULC projections under Mediterranean climate conditions. In light of swift global changes in both environmental and socioeconomic spheres, this proposed

framework enhances policy-related decision-making centres with improved and effective awareness and preparedness for future decisions.

Keywords: Land Use Land Cover Change, Remote Sensing, CLUE-S model, Multidimensional Drivers, Land Dynamics, Cyprus

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Securing the Nation’s Water Supply and Livelihoods Using Nature Based Solution

Stanley Liphadzi

Water Research Commission, South Africa

Abstract

Water is one of the limited resources in many regions of the world, and poor management of this resource has exacerbated water related challenges in the developing countries. As a water scarce country, South Africa socio-economic development and growth is intertwined with its water security status and risks. This paper is aimed at illustrating the connection and interdependencies existing between water security and the catchment activities. Special focus on the Maloti-Drakensberg water catchment area showed the impact of soil or land management on securing water resources to increase water security in South Africa. Soil erosion studies have warned about the huge amount of top soil removed and mobilized as sediments to rivers and dams or lakes. The eroded soil from upstream catchments don’t only impoverish agricultural fields (and farmers), but also reduce the water storage capacity of river’s pools, dams or lakes located downstream. Dam siltation or sedimentation contributes to dam wall’s degradation which compromise the safety of dams. The demand for water has become higher than the supply in many parts of South Africa due to the increasing population and increasing economic activities. The case studies showed that the best way to improve water security is to protect water at its source. South Africa has delineated and mapped sites that are called Strategic Water Source Areas. In addition, there are research and development projects and programmes implemented to protect these strategic water sources areas, which this paper will present.

Keywords: Dams, degradation, siltation, water security, water supply, water quality, water quantity

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TERRAENVISION-AN1-3611-Poster
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Landscape Connectivity and Multi-hazard Risk Management in the Zagros Mountains, Iran

Mohammad ali Kiani and Mehrnoosh Ghadimi

Faculty of Geography, University of Tehran, Iran

Abstract

Mountain landscapes are increasingly affected by the combined impacts of natural hazards, environmental degradation, and human pressure, creating complex challenges for sustainable management. The Zagros Mountains, one of the largest mountain systems in Southwest Asia, are characterised by active geomorphological processes, recurrent landslides, flash floods, soil erosion, and extensive land-use change. Previous studies have highlighted the importance of landscape connectivity and resilience for understanding environmental change and hazard propagation in mountain regions (Brierley et al., 2021; Fryirs, 2013), while investigations in the Zagros Mountains have demonstrated the sensitivity of geomorphological systems to climatic and environmental variability (Ghadimi et al., 2015; Ghadimi et al., 2019). This study explores the relationship between landscape connectivity and multi-hazard risk across the Zagros region using an integrated geospatial framework. Topographic, hydrological, ecological, and anthropogenic variables were analysed to identify areas where environmental disturbances can propagate through interconnected landscape systems and amplify hazard impacts. The results reveal that highly connected mountain corridors, particularly along steep catchments and densely utilised valleys, exhibit elevated vulnerability to cascading hazard processes. The analysis highlights the role of landscape structure in controlling the spatial distribution of risk and demonstrates that hazard management strategies focusing solely on individual processes may overlook critical interactions between environmental systems. The proposed approach supports the identification of priority areas for ecosystem restoration, risk reduction, and sustainable land management. By linking geomorphological dynamics with landscape-scale planning, this study provides new perspectives for enhancing resilience and supporting sustainable development in mountain regions exposed to multiple environmental hazards.

Keywords: Landscape Connectivity, Multi-Hazard Risk, Sustainable Land Management, Environmental Resilience

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Impact of Local Environmental Management on the Diversity and Availability of Economically Important Wild Food Plants in the Central Sumatra Traditional Markets

Afni Atika Marpaung[1,*], Fitmawati[2], Ewelina Klichowska[1] and Marcin Nobis[1]

[1]*Institute of Botany, Faculty of Biology, Jagiellonian University, Poland*
[2]*Department of Biology, Faculty of Mathematics and Natural Sciences (FMIPA), Riau University, Indonesia*

Abstract

Wild plants play an important role in the daily practices of local communities. However, modernisation and rapid natural habitat alteration in Central Sumatra (Indonesia) have threatened the local knowledge related to wild plants. Traditional markets serve as important ethnobotanical places where such knowledge is maintained and transmitted. This study examines the distribution patterns of useful wild plants in Riau across 58 traditional markets using semi-structured interviews. We used Canonical Correspondence Analysis (CCA) to assess plant distribution in relation to socio-ecological factors and compare species richness across land-use types. We found that 172 wild plant species are sold in the markets, and most of them are food plants. Our analyses revealed that markets tend to cluster geographically. The distribution of wild plants in the markets is influenced by the socioecological characteristics and ethnic diversity of the area. We also found that Markets located in areas dominated by monoculture plantations have low species richness and high plant homogeneity. Our findings show that the expansion of monocultures plantation in Riau is a threat to biodiversity and traditional knowledge. The result of our study highlights the need to conserve natural habitat for cultural continuity, livelihoods, and food security.

Keywords: Biodiversity, Deforestation, Edible plants, Ethnobotany, Monoculture plantation, Useful plant

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Nitrogen Management for Soil Carbon Stabilization in Arid Agroecosystems: Linking Aggregates, Microbes and Functional Carbon Pools

Lingling Li[1], Khuram Shehzad Khan[2,3,4,5], Artemi Cerdà[6,*], Tajwar Alam[7], Abdulaziz G. Alghamdi[8] and Rizwan Azim[8]

[1]*Department of Soil Science, College of Food and Agricultural Sciences, King Saud University, Riyadh 11451, Saudi Arabia*
[2]*State Key Laboratory of Aridland Crop Science, Gansu Agricultural University, Lanzhou 730070, China, China*
[3]*College of Agronomy, Gansu Agricultural University, Lanzhou 730070, China, China*
[4]*College of Resources and Environmental Sciences, National Academy of Agriculture Green Development, China Agricultural University, Beijing 100193, China, China*
[5]*Institute of Soil & Environmental Sciences, University of Agriculture Faisalabad, Faisalabad 38040, Pakistan, Pakistan*
[6]*Soil Erosion and Degradation Research Group, Department of Geography, University of Valencia, Valencia 46010, Spain, Spain*
[7]*Institute of Hydroponic Agriculture, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan, Pakistan*
[8]*College of Grassland Science, Gansu Agricultural University, Lanzhou 730070, China, China*

Abstract

Soil aggregate stability is a key control of soil organic carbon (SOC) protection, nutrient cycling and soil resilience, particularly in arid and semi-arid agroecosystems. Nitrogen (N) inputs can increase plant productivity and carbon inputs, but their effects on SOC storage are strongly dependent on application rate, soil conditions and microbial responses. This review synthesizes evidence from PubMed, Web of Science and Scopus on N-mediated changes in soil aggregation, aggregate-associated carbon fractions, microbial communities, functional genes and carbon-stabilization pathways in arid agricultural systems. The synthesis shows that N effects on SOC and soil structure are nonlinear. Moderate N inputs, commonly reported around 50–200 kg N ha^{-1} yr^{-1}, generally promote plant-derived carbon inputs, macroaggregate formation, microbial biomass and glomalin-related aggregation. In contrast, excessive N inputs, often above approximately 200–300 kg N ha^{-1} yr^{-1}, may increase microbial decomposition, soil acidification and SOC turnover, although thresholds vary with soil texture, climate and management. Nitrogen tends to stimulate labile carbon pools such as particulate organic carbon (POC), dissolved organic carbon and microbial biomass carbon more rapidly than stable mineral-associated organic carbon (MAOC). Long-term carbon sequestration therefore depends on the transfer of plant-derived and microbial-processed carbon into physically and mineral-protected pools. The review further identifies microorganisms as a

central link between N management, aggregate formation and SOC stabilization. Nitrogen alters microbial community composition, enzyme activities, interaction networks and carbon-cycle functional genes, while microbial residues contribute to stable SOC formation. Integrating N management with organic amendments can strengthen microbial functioning and SOC accumulation. We propose an integrated framework in which N availability regulates plant carbon inputs, microbial processing, aggregate formation and mineral protection. The findings support balanced, site-specific N management as a nature-based pathway for improving soil health, carbon sequestration and climate resilience in dryland agriculture.

Keywords: Soil aggregate stability, nitrogen management, soil organic carbon, microbial functions, arid agroecosystems

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Relative Cost-Effectiveness of Nature-based Systems for Mitigation of Diffuse Agricultural Pollution Across Diverse Landscapes in New Zealand

Paula Holland[1], Chris C. Tanner[2,*], Yvonne S. Matthew[2,3] and Rupert J. Craggs[2]

[1]*Earth Sciences New Zealand, New Zealand*
[2]*Earth Sciences New Zealand, Gate 10 Silverdale Rd, Kirikiriroa – Hamilton 3216, Aotearoa-New Zealand, New Zealand*
[3]*Concept Consulting Group, 1 Woodward St, Whanganui-a-Tara – Wellington 6011, Aotearoa-New Zealand, New Zealand*

Abstract

Pastoral agricultural landscapes vary widely in their topography, soils, and hydrological characteristics, requiring tailored approaches that target the dominant flow pathways of diffuse contaminant export. We examine how the cost-effectiveness of nature-based interceptive mitigation systems varies across farm typologies and hydrologic landscape types (HLTs) in New Zealand. Using a national-scale modelling framework, we build on previous work by incorporating detailed farm typology data, stream network characteristics, and hydrologic flow paths to assess the performance and cost of riparian buffers, constructed wetlands, detainment bunds, woodchip bioreactors and filamentous algal nutrient scrubbers for reduction of total nitrogen (TN), total phosphorus (TP), and sediment. Each farm typology is matched to a representative landscape classification using the River Environment Classification (REC2), and we estimate cost-effectiveness across a full range of contaminant reduction levels using an improved optimisation algorithm. Rather than focusing on fixed reduction targets, our analysis uses marginal abatement cost curves to illustrate the trade-offs involved in achieving progressively higher levels of mitigation. Results show that landscape permeability, climate, and profitability strongly influence the feasibility and optimal mix of mitigation systems. This farm- and landscape-specific approach enables more targeted and cost-efficient freshwater interventions and provides a decision-support tool to help prioritise investment where it will deliver the greatest environmental benefit.

Keywords: grazing, landscapes, pollution

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Soil Erosion in Citrus Plantations: a State-of-the-Art Review

Artemi Cerdà[1], Diego Gámiz Monterde[2], Antonio Giménez Morera[3] and Saskia Deborah Keesstra[4]

[1]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, España. artemio.cerda@uv.es, Spain*
[2]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, España., Spain*
[3]*Departamento de Economía y Ciencias Sociales, Escuela Politècnica Superior de Alcoy, Universidad Politècnica de Valencia. Plaza Ferrandiz y Carbonell s/n, 03801 Alcoy, Alacant, Spain, Spain*
[4]*Team Soil, Water and Land Use, Wageningen University and Research, Wageningen, the Netherlands., Netherlands*

Abstract

Soil erosion constitutes a major environmental and agronomic challenge in citrus plantations, particularly in Mediterranean and subtropical regions where orchards frequently occupy sloping terrain and experience highly variable rainfall. A global systematic review confirms that citrus orchards can exhibit severe soil loss when vegetation is removed and the soil is intensively managed (Niu et al., 2021). Conventional practices commonly maintain bare inter-rows through tillage or herbicide application to control weeds and reduce competition for water and nutrients. However, these practices expose the soil to raindrop impact, decrease surface roughness and organic-matter inputs, promote crust formation and reduce infiltration. Machinery traffic and drip irrigation can further increase soil compaction and spatially concentrate water, runoff and sediment transport (Di Prima et al., 2018; Cerdà et al., 2021). Research in eastern Spain has demonstrated that newly established citrus plantations on slopes can produce high runoff coefficients and erosion rates under intense rainfall, especially following major land levelling and mechanisation (Cerdà et al., 2009). Soil loss is controlled by interactions among rainfall erosivity, slope gradient, soil texture, antecedent moisture, plantation age, vegetation cover and management intensity. Nevertheless, comparison among studies remains difficult because monitoring methods, plot dimensions, rainfall characteristics and observation periods are poorly standardised (Niu et al., 2021). Vegetated inter-rows, spontaneous plant cover, catch crops, organic farming, reduced tillage and organic mulches are among the most promising nature-based solutions. Straw mulch can substantially delay runoff initiation and reduce sediment detachment in glyphosate-treated clementine orchards (Keesstra et al., 2019). Similarly, chipped pruning residues provide soil protection while reusing locally available agricultural waste, although their adoption depends on costs, machinery and policy support (Cerdà et al., 2018). Organic management can also improve soil organic carbon, aggregate stability, porosity and overall physical quality compared with tillage- and herbicide-based systems (Di Prima et al., 2018). Abandonment may promote vegetation

recovery and reduce erosion, but it can also affect water resources, fire risk and landscape management (Cerdà et al., 2019). Future research should prioritise long-term standardised monitoring, extreme rainfall events, rill and gully development, sediment connectivity and nutrient and pesticide transport. Integrating field experiments, UAV surveys, high-resolution modelling, economic assessment and farmer participation will be essential for designing site-specific strategies that conserve soil without compromising citrus productivity, fruit quality or farm profitability.

Measured erosion rates in citrus plantations vary widely according to soil management, slope, rainfall characteristics and monitoring method. Rainfall simulations in newly established citrus orchards on sloping land in eastern Spain recorded soil losses of approximately 2.4 Mg ha^{-1} during a single one-hour storm representing a five-year return period (Cerdà et al., 2009). These event-scale measurements demonstrate the high erodibility of mechanically disturbed and vegetation-free orchard soils, but they should not be directly interpreted as annual erosion rates.

Long-term measurements also reveal substantial differences among management systems. In a drip-irrigated citrus plantation in the eastern Iberian Peninsula, conventional tillage produced a cumulative soil loss of 6.87 Mg ha^{-1}, whereas plots with a grass cover lost only 0.0092 Mg ha^{-1}. Soil loss under tillage was therefore approximately 745 times greater than under permanent vegetation (Cerdà et al., 2021).

Rainfall-simulation experiments in glyphosate-treated clementine orchards measured an average soil loss of 439 g per 0.28-m^2 plot under bare-soil conditions. Applying straw mulch reduced this value to 73 g per plot and lowered sediment concentrations from 16.7 to 3.6 g L^{-1} (Keesstra et al., 2019). The wide range of recorded values confirms that soil cover is a dominant control on erosion. Nevertheless, differences in plot dimensions, rainfall intensity and measurement duration require caution when comparing experimental and long-term field rates (Niu et al., 2021).

Keywords: Citrus, erosion, soil, sustainable, land, degradation, desertification, hydrology, sediments

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A Comprehensive Bibliometric Review of Land Degradation in Africa

Samson Opeyemi Okeleye[1] and Artemi Cerdà[2]

[1]*Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Nigeria, Nigeria*
[2]*Soil Erosion and Degradation Research Group, Department of Geography, Universitat of València, Valencia, Spain*

Abstract

Land degradation is a major but underprioritized environmental challenge in Africa, yet the field's overall literature has rarely been mapped systematically to reveal how research has grown, clustered, and evolved. This study presents the first continent-wide bibliometric review of African land degradation research, characterizing its growth, structure, and thematic evolution, and examining reported drivers. A focused search in OpenAlex yielded 143 English-language articles and reviews (2006–2026), analyzed using Bibliometrix/Biblioshiny for annual production trends, citation performance, collaboration networks, and thematic mapping. This quantitative analysis was complemented by qualitative content analysis of the 18 most globally cited publications and 7 representative emerging-topic publications (2022–2026), coded for reported drivers, consequences, methodological approaches, and research gaps. Publication output grew modestly but unevenly (annual growth rate of 2.59%), led by South African institutions within a broadly collaborative, internationally connected research network. Climatic variability (94%) and overgrazing/livestock pressure (67%) dominated as reported drivers, while soil organic carbon loss and vegetation/biodiversity decline (56% each) dominated as reported consequences. Soil microbial responses were addressed in 11% of the high-impact literature and were absent entirely from the emerging-topic sample. These findings indicate that African land degradation research remains thematically imbalanced, disproportionately favoring climatic and vegetation-based indicators over soil-biological processes. The consistent neglect of soil microbial responses across both samples represents a genuine, structural evidentiary gap rather than an artefact of citation bias, leaving a critical mechanistic link in the degradation-to-productivity pathway empirically unexamined. Future primary research that directly pairs remote-sensing, survey, or productivity-based degradation assessment with soil-biological sampling is needed to close this gap and support a more evidence-based foundation for land restoration policy across the continent.

Keywords: Soils, Africa, Desertification, Salinization, Deforestation, Research, Bibliography

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Vegetation Cover as a Nature-Based Solution to Reduce Soil Erosion in Citrus Plantations

Jesus Rodrigo-Comino[1], Artemi Cerdà[2,*], Diego Gamiz Monterde[2], Antonio Giménez Morera[3], Jesus Barrena[4], Saskia Keesstra[5], Saeedreza Moazeni[2,6], Samson Opeyemi Okeleye[7,2] and Leonardo de Aro Galera[8,2]

[1]*Departamento de Análisis Geográfico Regional y Geografía Física, Facultad de Filosofía y Letras, Campus Universitario de Cartuja, Universidad de Granada, 18071 Granada, Spain*
[2]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, España, Spain*
[3]*Departamento de Economía y Ciencias Sociales, Escuela Politècnica Superior de Alcoy, Universidad Politècnica de Valencia. Plaza Ferrandiz y Carbonell s/n, 03801 Alcoy, Alicante, Spain, Spain*
[4]*Departamento de Geografía, Universidad de Valladolid, España. J, Spain*
[5]*Team Soil, Water and Land Use, Wageningen University and Research, Wageningen, the Netherlands., Netherlands, Netherlands*
[6]*Department of Reclamation of Arid and Mountainous Regions, University of Tehran, Iran, Iran*
[7]*Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Nigeria, Nigeria*
[8]*Department of Soil Science, Luiz de Queiroz College of Agriculture (ESALQ), University of São Paulo (USP), Piracicaba, São Paulo, Brazil., Brazil*

Abstract

Soil erosion is a major environmental challenge in Mediterranean citrus plantations, where intensive management, tillage, herbicide application, and the consequent reduction of vegetation cover frequently expose the soil surface to rainfall and overland flow (Cerdà et al., 2009; Keesstra et al., 2019). High-intensity Mediterranean rainfall can generate substantial runoff and sediment losses, particularly in recently established orchards on sloping terrain (Cerdà et al., 2009). Vegetation and ground cover can substantially reduce these losses by protecting the soil against raindrop impact, increasing surface roughness and infiltration, and reducing runoff connectivity (Liu et al., 2012; Cerdà et al., 2018; Rodrigo-Comino et al., 2018). Consequently, maintaining vegetation cover represents a promising nature-based strategy for improving the sustainability of Mediterranean citrus production. Rainfall simulation experiments were carried out following the methodology developed by Cerdà for the assessment of soil hydrological and erosional responses under Mediterranean conditions. Rainfall was applied at an intensity of 55 mm h^{-1} for 60 min over a 1 m^2 surface, while runoff and sediment were collected from a 0.25 m^2 plot located in the central part of the wetted area. The simulator was positioned approximately 2 m above the soil surface to reproduce natural raindrop characteristics. Runoff was collected at one-minute intervals, and sediment concentration was determined from runoff samples to calculate soil loss. Prior to each experiment, vegetation cover, soil surface characteristics and antecedent soil moisture were

recorded. This standardized experimental design allowed direct comparison of runoff generation, infiltration and soil erosion between citrus plots with contrasting vegetation cover. The system is also characterized by droplets of approximately 2.5 mm, a fall velocity of about 3.4 m s^{-1} and kinetic energy of approximately 7.1 J m^{-2} mm^{-1} which has a 5 year return period in the study area The results shows a reduction in the soil losses as a consequence of the vegetation cover. Plots with less than 5 % plant cover results in soil erosion larger than 3 Mg ha-1 y-1. And plots with more than 50 % plant cover the soil losses were reduced to 0.2 Mg ha-1 y-1.

Keywords: Soil, Erosion, Citrus, Plant, Nature-based Solution, Runoff

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The Importance of Agricultural Terraces in Runoff Generation and Soil Loss Control

Eduardo Augusto Agnellos Barbosa[1], Artemi Cerdà[2,*] and Éricles Leonardo dos Santos[1]

[1]*Department of Soil Science and Agricultural Engineering, State University of Ponta Grossa (UEPG)., Brazil*
[2]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, Spain, Spain*

Abstract

The Importance of Agricultural Terraces in Runoff Generation and Soil Loss Control Agricultural terraces are among the oldest and most widespread strategies for cultivating sloping land while conserving soil and water resources. By shortening slope length and reducing its gradient, terraces modify the movement of water across hillslopes, promote infiltration, decrease runoff velocity and limit sediment transport (Arnáez et al., 2015; Wei et al., 2016; de Paula et al., 2026). Nevertheless, their hydrological and geomorphological effects vary considerably according to terrace design, soil properties, rainfall intensity, vegetation cover, cultivation practices and maintenance conditions. This course examines the role of agricultural terraces in runoff generation, hydrological connectivity and soil erosion, with particular attention to Mediterranean and other mountainous landscapes, such as agricultural landscapes in Paraná, Brazil.. Properly designed and maintained terraces generally reduce surface runoff and soil loss, improve soil-water retention and limit sediment delivery to downstream areas (Ran et al., 2020; Zhao et al., 2021). Conversely, the deterioration of terrace walls and drainage structures may concentrate runoff, reconnect natural drainage pathways and initiate rilling, gullying, piping, mass movements or cascading terrace failures (Moreno-de-las-Heras et al., 2019). The programme will introduce the principal methods used to investigate these processes, including rainfall simulations, runoff plots, sediment monitoring, soil-property assessment, remote sensing, unmanned aerial vehicle surveys and hydrological modelling. Comparative case studies will demonstrate how climate, topography, lithology, land use and vegetation interact to determine the hydrological response and erosional stability of terraced landscapes. Particular attention will be paid to agricultural abandonment. Its effects are not uniform: vegetation recovery may decrease runoff and surface erosion, whereas insufficient plant cover and the deterioration of terrace structures can increase hydrological connectivity and erosion risk (García-Ruiz & Lana-Renault, 2011; Rodrigo-Comino et al., 2018). In Mediterranean environments, the stability of abandoned terraces depends particularly on vegetation development, lithology, rainfall regime and the structural condition of walls and drainage systems (Moreno-de-las-Heras et al., 2019). Finally, the course will examine how increasingly extreme rainfall, rural depopulation and insufficient maintenance threaten traditional terraced landscapes. Participants will assess management options ranging from

continued cultivation and structural rehabilitation to vegetation restoration and managed rewilding. Terraces will therefore be considered multifunctional landscapes whose conservation contributes to sustainable agriculture, water regulation, erosion control, climate adaptation, biodiversity and cultural heritage.

Keywords: Agricultural terraces, runoff, Soil erosion, Soil loss, Hydrological connectivity, Land abandonment, Mediterranean landscapes, Soil and water conservation

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Biochar as a Soil Amendment to Mitigate the Impacts of Land Degradation

Artemi Cerdà[1,*], Samson Opeyemi Okeleye[2], Diego Gamiz Monterde[1] and Antonio GImínez Morera[3]

[1]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, Spain, Spain*
[2]*Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Nigeria, Spain*
[3]*2Departamento de Economía y Ciencias Sociales, Escuela Politècnica Superior de Alcoy, Universidad Politècnica de Valencia. Plaza Ferrandiz y Carbonell s/n, 03801 Alcoy, Alicante, Spain, Spain, Spain*

Abstract

Land degradation is a major global environmental challenge that reduces soil productivity, threatens food security, diminishes biodiversity and weakens the capacity of terrestrial ecosystems to regulate water and climate. It results from interacting processes such as soil erosion, organic-matter depletion, compaction, acidification, salinisation, nutrient loss and contamination. Conventional restoration practices often require repeated applications of fertilisers, lime, compost or other materials whose effectiveness and economic viability may decline over time. Biochar has therefore attracted attention as a potentially long-lasting soil amendment capable of addressing several forms of degradation simultaneously.
Biochar is a carbon-rich, porous material produced through the thermochemical conversion of biomass under oxygen-limited conditions. Feedstocks may include crop residues, forestry waste, manure and selected organic by-products. Pyrolysis converts part of the original biomass carbon into relatively stable aromatic structures, allowing biochar to remain in soil longer than most uncharred organic amendments. When biochar production uses sustainably sourced residues and controls emissions, it can contribute to climate-change mitigation while returning carbon and nutrients to soils (Woolf et al., 2010). Nevertheless, biochar is not a uniform product: feedstock composition, pyrolysis temperature, residence time and post-production treatment determine its pH, porosity, surface chemistry, nutrient content and potential contaminants.
One of biochar's most relevant contributions to restoring degraded soils is the improvement of physical structure. Many degraded soils exhibit high bulk density, weak aggregation, surface crusting and restricted root penetration. Because biochar generally has a lower density and greater porosity than mineral soil, its incorporation can reduce bulk density and increase total porosity. It may also improve aggregate stability by modifying particle associations and stimulating biological binding processes. A broad review found that biochar frequently improves soil physical conditions, although responses are generally stronger in coarse-textured soils than in fine-textured soils and vary substantially with particle size and application rate (Blanco-Canqui, 2017).

These structural changes influence water storage and movement. Biochar particles contain internal pores that may retain water, while their incorporation changes the size and connectivity of pores between soil particles. A systematic review and meta-analysis found that biochar reduced bulk density and increased plant-available water, with the greatest improvements occurring in coarse-textured soils. Effects were smaller and less consistent in fine-textured soils, demonstrating that biochar should be matched to the properties of the receiving soil (Li et al., 2020). Improved water retention may enhance drought resilience and plant establishment on dry or disturbed land. However, inappropriate particle sizes or application rates may alter hydraulic conductivity unpredictably, while some highly hydrophobic fresh biochars can initially repel water.

Soil erosion is another central process linking land degradation, declining fertility and sediment pollution. Biochar may reduce erosion by improving aggregation, infiltration, surface roughness and vegetation development. A global meta-analysis reported average reductions of approximately 25% in runoff and 16% in water-driven soil erosion following biochar application. The effect was stronger when biochar was combined with vegetation, indicating that biochar should complement rather than replace plant cover and other conservation measures (Bekchanova et al., 2024). Effective restoration should therefore integrate biochar with cover crops, mulching, contour planting, reduced tillage or agroforestry.

Chemically degraded soils may benefit from biochar's liming capacity, surface charge and nutrient-retention properties. Many biochars increase soil pH and cation-exchange capacity, particularly in acidic and sandy soils. Their surfaces can retain ammonium, potassium, calcium and other nutrients, potentially reducing leaching and improving fertiliser-use efficiency. A global meta-analysis found positive effects on soil organic carbon, total carbon, pH and cation-exchange capacity, but identified application rate, initial soil pH and sand content as major controls over the magnitude of these responses (Sun et al., 2022).

Keywords: Biochar, soil amendment, land degradation, soil restoration, erosion, soil carbon, water retention, nutrient cycling, contaminated soil, climate mitigation

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Vegetation and Evapotranspiration Response to Watershed Restoration: a Case Study of Vardij Watershed, Iran

Zahra Sadat Hosseini[1], Saeedreza Moazeni[2,3] and Artemi Cerdà[3,*]

[1]*Department of Range and Watershed Management, Faculty of Natural Resources and Environment, Ferdowsi University of Mashhad (FUM), Mashhad, Khorasan Razavi, Iran*
[2]*Department of Reclamation of Arid and Mountainous Regions, University of Tehran, Karaj, Iran*
[3]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, España, Spain, Spain*

Abstract

Vegetation restoration is an important component of watershed management in semi-arid regions, where vegetation dynamics are closely linked to water availability and land-surface conditions. This study evaluated long-term changes in vegetation and actual evapotranspiration following watershed restoration measures in the 328-ha Vardij Watershed, Iran. Annual NDVI, actual evapotranspiration (ET), and precipitation were analyzed for the period 2001–2025, with 2013 considered as the reference year for the implementation of biological and mechanical soil and water conservation measures. The results showed a clear improvement in vegetation conditions after the interventions. Mean NDVI increased by about 11% compared with the pre-restoration period, while the rate of NDVI increase was more than three times higher than before the interventions. In contrast, mean annual precipitation decreased by about 9%, whereas mean annual ET increased by approximately 5%. Spatial analysis also indicated a greater presence of higher NDVI classes, particularly in the central and southern parts of the watershed after restoration. The simultaneous increase in vegetation greenness and ET under lower mean precipitation suggests that the response of the watershed was not controlled by rainfall alone. Improved infiltration, greater retention of rainfall within the soil–vegetation system, and better availability of stored water following soil and water conservation measures may have contributed to sustaining vegetation growth and increasing water use by vegetation. Overall, the results indicate a positive long-term response of the Vardij Watershed to restoration measures and demonstrate the value of multi-temporal remote sensing for assessing vegetation and hydrological responses to watershed management in semi-arid environments.

Keywords: Watershed restoration, NDVI, Actual evapotranspiration, Remote sensing, Iran

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Land Restoration in Africa: a Systematic Thematic Review

Samson Opeyemi Okeleye[1], Artemi Cerdà[2,*] and Abayomi Tolulope Oyewale[3]

[1]*Institute of Ecology and Environmental Studies, Obafemi Awolowo University (OAU), NigeriaInstitute of Ecology and Environmental Studies, Obafemi Awolowo University (OAU), Nigeria, Nigeria*
[2]*Soil Erosion and Degradation Research Group, Department of Geography, Universitat of València, Valencia, Spain, Spain*
[3]*Institute of Ecology and Environmental Studies, OAU, Nigeria, Nigeria*

Abstract

Land degradation affects a large share of Africa's croplands, rangelands, and forests, prompting continental initiatives such as AFR100 and the Great Green Wall, yet the rapidly expanding body of African land-restoration research has not been systematically synthesized across approaches, contexts, and outcomes. This study addresses that gap by characterizing the research landscape, thematic focus, and evidence gaps of land-restoration research in Africa.
Bibliometric analysis (Bibliometrix/Biblioshiny) was combined with Text-Analysis-for-All (TALL)-assisted thematic coding of 131 peer-reviewed articles and reviews on land restoration in Africa (2006–2026), retrieved from OpenAlex following a PRISMA-adapted screening process, to characterize the field's research landscape, restoration themes, geographical and ecological contexts, outcomes, temporal trends, and governance dimensions.
Annual publication output rose from single articles before 2010 to 10–14 articles annually after 2019, concentrated in Ethiopia (34.9%) and Egypt (17.1%). Agroforestry-based (29.0%) and engineering-based reclamation (28.2%) approaches dominated, while erosion/landform rehabilitation and soil-microbial outcomes remained near-absent (under 2%). Socioeconomic outcomes were reported nearly twice as often as any biophysical outcome (32.6%), and only 19.1% of studies combined multiple restoration themes. Ecosystem/landscape restoration, governance/adoption assessment, and soil-and-water conservation emerged as growing themes after 2016, while stakeholder-participation reporting rose from 5% to 33% across periods, even as institutional-mechanism and policy-barrier documentation remained rare.
African land-restoration research is expanding and diversifying thematically, but remains geographically concentrated, methodologically fragmented, and weak in ecological-outcome verification, particularly for reclamation and mine-rehabilitation approaches. Closing these gaps requires paired ecological–socioeconomic evaluation, multi-country monitoring matched to programme scale, and expanded research coverage of underrepresented regions and ecosystems.

Keywords: land restoration, land degradation, sub-Saharan Africa, agroforestry, ecosystem restoration, governance

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Land Restoration in Africa: a Systematic Thematic Review

Samson Opeyemi Okeleye[1], Artemi Cerdà[2,*] and Abayomi Tolulope Oyewale[3]

[1]*Institute of Ecology and Environmental Studies, Obafemi Awolowo University (OAU), NigeriaInstitute of Ecology and Environmental Studies, Obafemi Awolowo University (OAU), Nigeria*
[2]*Soil Erosion and Degradation Research Group, Department of Geography, Universitat of València, Valencia, Spain*
[3]*Institute of Ecology and Environmental Studies, OAU, Nigeria*

Abstract

Land degradation affects a large share of Africa's croplands, rangelands, and forests, prompting continental initiatives such as AFR100 and the Great Green Wall, yet the rapidly expanding body of African land-restoration research has not been systematically synthesized across approaches, contexts, and outcomes. This study addresses that gap by characterizing the research landscape, thematic focus, and evidence gaps of land-restoration research in Africa. Bibliometric analysis (Bibliometrix/Biblioshiny) was combined with Text-Analysis-for-All (TALL)-assisted thematic coding of 131 peer-reviewed articles and reviews on land restoration in Africa (2006–2026), retrieved from OpenAlex following a PRISMA-adapted screening process, to characterize the field's research landscape, restoration themes, geographical and ecological contexts, outcomes, temporal trends, and governance dimensions. Annual publication output rose from single articles before 2010 to 10–14 articles annually after 2019, concentrated in Ethiopia (34.9%) and Egypt (17.1%). Agroforestry-based (29.0%) and engineering-based reclamation (28.2%) approaches dominated, while erosion/landform rehabilitation and soil-microbial outcomes remained near-absent (under 2%). Socioeconomic outcomes were reported nearly twice as often as any biophysical outcome (32.6%), and only 19.1% of studies combined multiple restoration themes. Ecosystem/landscape restoration, governance/adoption assessment, and soil-and-water conservation emerged as growing themes after 2016, while stakeholder-participation reporting rose from 5% to 33% across periods, even as institutional-mechanism and policy-barrier documentation remained rare. African land-restoration research is expanding and diversifying thematically, but remains geographically concentrated, methodologically fragmented, and weak in ecological-outcome verification, particularly for reclamation and mine-rehabilitation approaches. Closing these gaps requires paired ecological–socioeconomic evaluation, multi-country monitoring matched to programme scale, and expanded research coverage of underrepresented regions and ecosystems.

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Agrivoltaics and Extensive Livestock Farming: Soil, Thermal, and Geomorphometric Evaluation of Solar Grazing in Rural Granada

Jesús Rodrigo-Comino, José Luis Serrano Montes, Laura Cambronero Ruiz and Lucía Moreno Cuenca

University of Granada, Spain

Abstract

The shift toward renewable energy and the expansion of solar projects increasingly compete with extensive livestock farming for a vital strategic asset: land. To address this land-use competition, solar grazing has emerged as a novel practice that merges renewable electricity generation with traditional grazing within the same perimeter, maximizing territory utility and mitigating friction between industries. This research communication highlights early findings from an ongoing study based in Granada province, an administrative territory experiencing rapid solar development that raises critical questions regarding agricultural, territorial, and visual impacts. The core objective is to evaluate the spatial scale of photovoltaic facilities across the province and assess their direct effect on pasture availability and functionality for livestock producers. Furthermore, the project captures the viewpoints, goals, and expectations of local stakeholders to determine the conditions under which solar grazing fosters sustainable energy and farming management.

The initial phase documented in this paper relies on drone-based measurements using the DJI Mavic 3M and Matrice T4 platforms to generate detailed geomorphometric and thermal maps and evaluate direct soil impacts. Field methodology further incorporates penetrometer testing and laboratory analysis to measure differences in soil water retention capacity alongside key properties such as organic matter, pH, electrical conductivity, and aggregate stability. This integrated spatial and edaphic evaluation helps clarify how solar installations influence forage accessibility for extensive herds. Anticipated outcomes point toward notable environmental advantages—such as enhanced soil conservation and lower ecological disruption—alongside financial gains driven by revenue diversification and reduced operating expenses. Ultimately, the study sheds light on perceived obstacles and catalysts among participants, promoting the scalability of this practice to achieve a socially equitable ecological transition.

Keywords: Agricoltaics, geomorphology, regional studies, UAV

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AN4: Nature-Based Solutions in Agriculture: Innovations, Evidence, and Practice

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Canopy Microclimate Modification and Plant–Soil Interactions in Basil Under Manti Shading

Szilvia Kisvarga[1], Katalin Horotán[2], Zsanett Istvánfi[1] and László Orlóci[1]

[1]*Hungarian University of Agriculture and Life Sciences, Hungary*
[2]*Eszterházy Károly Catholic University, Hungary*

Abstract

The microclimate within the plant canopy is a key factor in horticultural production systems because radiation load and temperature conditions directly influence leaf energy balance, transpiration and photosynthetic performance. During summer periods, high irradiance and heat waves often occur simultaneously and create stress conditions that can constrain plant growth and biomass accumulation. For this reason, shading technologies are widely used in protected cultivation to mitigate radiation and heat stress. However, conventional shading systems frequently reduce photosynthetically active radiation together with heat load, which in some cases may limit plant growth. In recent years, increasing attention has been directed towards nano-modified covering systems that regulate the optical properties of surfaces. These materials can influence radiation reflection and scattering, allowing modification of the canopy microclimate while maintaining similar levels of light transmission.

The aim of the present study was to examine how a nano-material–modified shading system (MANTI) affects growth responses and biomass allocation patterns in basil (*Ocimum basilicum* L.), and how these plant responses relate to processes occurring in the root zone. The experiment was conducted at the experimental horticultural station of the Hungarian University of Agriculture and Life Sciences in Budapest. Basil plants were cultivated in a raised-bed system under two canopy environments: an uncovered control and a nano-modified shading treatment. During the cultivation period, canopy microclimate conditions were continuously monitored, and plant growth parameters, root traits and selected soil biological indicators were evaluated.

The results indicated that technological modification of the radiation environment can significantly influence basil development. Plants grown under the MANTI covering exhibited altered vegetative growth patterns, reflected in differences in leaf formation and biomass distribution within the plant. These findings suggest that canopy microclimate conditions may affect plant growth strategy rather than simply increasing or decreasing total biomass production. Differences observed in root traits further indicate that changes in canopy environment can influence carbon allocation to the root zone. Because root-derived carbon inputs regulate microbial activity in the rhizosphere, these shifts may also affect soil biological processes. The results therefore suggest that the evaluation of microclimate regulation technologies can be improved when plant growth responses and rhizosphere processes are analysed together in horticultural production systems.

Keywords: basil, microclimate regulation, nano-modified shading, biomass allocation, rhizosphere

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Biochar Suspension as a Nature-based Solution to Enhance Phosphorus Efficiency in Agroecosystems

Iryna Loginova[1,*], Nataliya Bilyera[1], Svenja Stock[1], Callum Banfield[1], Denis Kutoley[2], Serhii Polianchykov[2], Nikolas Hagemann[3], Yakov Kuzyakov[4] and Michaela A. Dippold[1]

[1]*Geo-Biosphere Interactions, Department of Geosciences, University of Tübingen, Tübingen, 72076, Germany*
[2]*R&D department, Research and Production Company KVADRAT, Kharkiv, 61001, Ukraine*
[3]*Agroscope, Zürich, 8046, Switzerland; Ithaka Institute for Carbon Strategies, Goldbach, 63773, Germany; Arbaz, 1974, Switzerland*
[4]*Department of Soil Science of Temperate Ecosystems, Department of Agricultural Soil Sciences, University of Göttingen, Göttingen, 37077, Germany*

Abstract

Biochar (BC) is a promising nature-based solution for improving the sustainability and resilience of agricultural systems. Derived from agricultural residues, it supports circular economy principles while contributing to carbon sequestration and resource efficiency. When used as a suspension, BC can be co-applied with liquid phosphorus (P) fertilisers to stimulate microbial activity, enhance P cycling, and improve plant P nutrition. The localized co-application of BC and P is a practical, nature-based approach that is particularly suited to degraded soils, reduced tillage systems, and drought-prone conditions. It reduces operational costs and supports broader adoption. However, interactions within localized ‘charosphere’ hotspots remain poorly understood.

Our study aimed to identify the potential synergistic effects of applying a corncob BC suspension (300 kg dry BC ha-1) and a liquid P fertiliser (30 kg P ha-1, 33P-labelled), as a localized band near maize seeds. Specifically, we targeted to clarify the underlying mechanisms of soil P transformation and plant nutrition by examining shifts in soil and microbial C:P stoichiometry, microbial responses, P (im)mobilization, and early maize P uptake in a rhizobox experiment. The treatments included sole BC, sole P, BC+P, and an unfertilised Control.

Joint BC and P application balanced soil-microbial C:P stoichiometry compared to sole P or BC, maintained high microbial biomass, and reduced both C- and P-acquiring enzyme activities, indicating more efficient microbial resource use. In contrast, sole BC increased dissolved organic C and stimulated C-acquiring enzyme activity without affecting microbial biomass, whereas sole P increased soil P availability, but also induced a strong soil-microbial C:P imbalance, potentially increasing P loss and abiotic immobilization.

Soil zymography-based enzyme imaging showed that root-associated enzymatic activity was primarily regulated by P availability rather than BC addition. ^{33}P labelling and imaging confirmed that BC did not restrict P movement from the fertiliser band. Up to 25% of the

applied P remained in the available soil P pool after 38 days, regardless of BC. Furthermore, BC increased P recovery in young maize (5-leaf stage) from 15% to 18%, indicating improved P use efficiency.
Overall, the localized co-application of BC suspension and mineral P fertiliser increases P use efficiency and promotes more efficient microbial resource use, supporting soil microbial functioning and plant nutrition. Applied at low, economically viable rates (< 1 t ha-1), BC suspension offers a practical, nature-based solution that restores soil fertility and supports the sustainable recovery of agricultural productivity.

Keywords: band application, biochar suspension, 33P labelling, P nutrition, soil imaging

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Assessing the Performance of a Reactive Ditch Treating Agricultural Drainage Water in Northern Germany

Ramodh Jayawardena[1,*], Lishani Wijewardena[2], Nicola Fohrer[1] and Uta Ulrich[1]

[1]*Institute for Natural Resource Conservation, Kiel University, Germany*
[2]*Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka*

Abstract

Agricultural drainage is a major source of nutrient pollution, particularly nitrogen (N), in aquatic ecosystems (Burbery et al., 2022). This problem requires treatment systems that decrease the nutrients, and other agrochemical contents of agricultural drainage water before entering surface water bodies. At the same time, they have to be cost-effective, low maintenance and user-friendly. Reactive ditches (RDs) also referred to in the literature as denitrifying bioreactors, woodchip bioreactors, and denitrification beds are a nature-based technology (Rivas et al., 2020). This study evaluated the treatment performance and internal process dynamics of a RD with a volume of 44.4 m^3, treating agricultural drainage water in Kiel, northern Germany, during the winter in 2025. Daily inlet and outlet samples were collected and analyzed for ammonia (NH_4^+-N), nitrite (NO_2^--N), nitrate (NO_3^--N), phosphate (PO_4^{3-}-P), total phosphorus (TP), and sulphate (SO_4^{2-}) over 27 days. Continuous hourly measurements of dissolved oxygen (DO), redox potential, pH, and temperature were recorded at three internal sensors positioned at 2 m, 18 m, and 37 m from the inlet. Three functional zones in RD were identified as oxic (near inlet), denitrifying (middle) and sulphate reducing (near outlet) with mean redox potential of 517±35, -23±69 and -265±141 mV respectively. Similarly, DO also showed same pattern, decreasing from 1.6±1.5 to 0.1±0.5 mg/L along the RD length. Temperature varied in between 6.0–6.8 °C and pH remained stable along the length. The RD received a sum of NH_4^+-N, NO_2^--N and NO_3^--N of 357.1±138.0 g N/day and removed 5.2 kg over the monitoring period at volumetric removal rates of 5.2-14.6 g N/m^3/day. A linear relationship between loading rate and removal rate (slope = 0.996, R^2 = 0.9998) suggested the RD was operating below its maximum treatment capacity, with further removal potential at higher loading rates. The removal was statistically significant for PO_4^{3-}-P (p = 0.001) and SO_4^{2-} (p = 0.021), with positive removal observed on the majority of monitoring days. However, TP exhibited net release on most days. These results confirm that RDs can achieve near-complete N removal under cold winter conditions without reaching treatment capacity, while providing practical guidance for the design and application of nature-based treatment systems for agricultural drainage water.

Keywords: Woodchip bioreactor, Denitrification bed, Nitrogen removal, Nature-based solution

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Composting Suitability of Aged Woodchips From Reactive Ditches

Uta Ulrich[1,*], Ramodh Jayawardena[1], Lishani Wijewardene[2] and Nicola Fohrer[1]

[1]*Institute of Natural Resource Conservation, Kiel University, Germany*
[2]*Department of Limnology & Water Technology, University of Ruhuna, Sri Lanka*

Abstract

Reactive Ditches (RDs) are nature-based treatment systems generally implemented for agricultural water management. Though, disposal of aged woodchips after a long-term operation represents a considerable challenge to farmers. This study evaluated whether aged woodchips from a RD operated for three years could be reused as compost, directly assessed against German BioAbfV composting standards. Thirty-six aged woodchip samples from six locations along the RD length with replicate depths (top and bottom) at each location were collected. Physical parameters (ash content, moisture content, pH, electrical conductivity (EC), chemical composition (phosphorous (P), potassium (K), ammonia (NH4+-N), sulphate (SO42-), chloride (Cl-), nitrite (NO3--N), and heavy metals (Pb, Cd, Cr, Cu, Zn) were quantified. Data was analyzed statistically to evaluate the location and depth effects on woodchip quality, spatial trends and assessed the compliance against German BioAbfV composting standards. Ash content increased significantly from inlet to outlet ($R2=0.212$, $p=0.005$), indicating increasing woodchip degradation. Conversely, other parameters declined towards the outlet, with Cl- showing the strongest trend ($R2=0.333$, $p<0.001$). Importantly, ash content did not correlate with chemical parameters, indicating that woodchip degradation and change in chemical composition are independent mechanisms. Two-way ANOVA revealed highly significant effects of depth on EC ($F=60.55$, $p<0.001$) and SO42- ($F=29.10$, $p<0.001$), with bottom samples having lower pH due to organic acid accumulation. Ash content ($H=18.97$, $p=0.002$) and Cl- ($H=29.12$, $p<0.001$) varied significantly by location, while NH4+-N and NO3--N remained uniformly along the RD. Heavy metal concentrations were less than the BioAbfV limits, within the range of 0.0002 - 0.0693 mg/kg. Compliance against BioAbfV revealed that all the samples were within the defined limits for heavy metals, pH and NH4+-N. 83% of the samples met the recommended K concentrations while EC and moisture content were not within the range for all the samples. Only a few samples achieved the ash content limits, indicating that woodchips require more degradation before they use for composting. Nevertheless, this study suggests that woodchips can be used for composting with only minor post treatment.

Keywords: BioAbfV compliance, reusing woodchips, nature-based solutions

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A Systematic Review of Runoff and Soil Erosion Control Measures in Agricultural Landscapes

Abobakr Hussin

Institute for Land and Water Management Research, Federal Agency for Water Management, Austria

Abstract

Control interventions play a critical role in reducing surface runoff and soil erosion in agricultural landscapes, particularly amid increasing climate variability and intensifying land-use pressures. This systematic review, conducted in accordance with PRISMA 2020 standards, synthesizes findings from 380 studies published between 1995 and 2025 across 20 countries. We evaluate the effectiveness of a wide range of control mitigation measures, compares methodological approaches, and identifies geographic and temporal research.
Through the more than 17 measures types investigated and structured measures (e.g., grassed waterways including a small retention basin) provided the greatest peak flow attenuation, with a maximum reported reduction of 69 percent. The majority of measures were highly effective in controlling sediment (e.g., Conservation tillage, buffer strips, mulching and residue management) this performance depended on scale, slope of area drained, rainfall intensity, and texture of soil.
A key methodological insight emerged regarding experimental design: studies employing simulated rainfall tended to underestimate runoff reduction relative to field studies under natural rainfall (e.g., for riparian buffer strips and geotextile-based controls). This discrepancy is attributed to challenges in replicating realistic flow lengths, widths, and hydraulic roughness in experimental plots, all of which influence surface flow and infiltration dynamics. In contrast, erosion reduction metrics were found to be more consistent across methodological approaches.
Upon completion of the remaining datasets currently in progress, our work will provide a comprehensive evidence base for context-appropriate erosion control selection and implementation. Future deliverables include incorporating site characteristics and assessment of measure performance. The completed synthesis will support policymakers, agricultural practitioners, and watershed managers in developing climate-resilient land and water resource management strategies based on scientific evidence

Keywords: systematic review, erosion control, agricultural landscapes, surface runoff, soil erosion, terraces, conservation tillage, grass waterways, buffer strips, geotextiles, Europe, PRISMA 2020, meta-analysis, site-specific effectiveness

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Freshgraze: Rethinking “Normal” Grazing Behaviour to Enable Nature-Based Farming

Thomas Drumm

Farmer Innovator, Pioneer (Freshgraze), Ireland

Abstract

Modern pasture agriculture has often treated grazing behaviour observed within static fields and simplified monocultural swards as “normal”, then sought to optimise production by refining that system through inputs, measurement and control. Freshgraze began within this conventional framework, but on-farm trials produced unexpected changes in animal behaviour when the grazing boundary was continuously moved.

These observations forced us to question an assumption: what is routinely observed is not necessarily biologically normal; it may be behaviour created by the production system itself. If grazing behaviour is shaped by fixed boundaries, simplified plant communities and established management practices, then improving that system may only refine the limitations it has created.

Freshgraze is an autonomous moving-fence and cyber-physical grazing system designed to recreate key features of how animals grazed as mobile herds across open landscapes before fixed field boundaries. By continuously changing access to pasture, it alters how animals encounter and utilise the sward. Early trials indicate that these changes create new possibilities for managing diverse swards and interactions between livestock, plants, roots, soil organisms and the farmer.

This change in understanding led us to ask: how can food production be designed as a nature-based solution, working with animal behaviour, plant diversity and ecological processes rather than simplifying them for operational convenience?

This presentation will share the observable behavioural and early field outcomes that led to this systems hypothesis, discuss their implications for managing complex agroecosystems, and outline priorities for independent evaluation of productivity, soil health, biodiversity, resilience, animal performance and wider applicability.

Keywords: grazing behaviour, diverse swards, agroecosystem management, Soil heath

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An Ecosystem Service-Based Cost-Benefit Framework for Evaluating Environmentally-Technical Areas in Agricultural Landscapes

Jan Macháč, Marek Hekrle and Lenka Zaňková

J. E. Purkyne University in Usti nad Labem, Czech Republic

Abstract

Agricultural landscapes increasingly face soil degradation, erosion, and reduced water retention, creating a need for measures that combine productive land use with enhanced ecological functions. Nature-Based Solutions (NBS) can address these challenges while generating multiple ecosystem services. However, their implementation also involves investment and maintenance costs and may reduce agricultural production. A comprehensive assessment therefore requires an evaluation framework that captures both direct economic effects and wider societal benefits.

This study presents an ecosystem service-based cost-benefit framework for evaluating environmentally-technical areas (ETAs) created through the spatial optimization of agricultural land. ETAs represent non-productive or extensively managed areas integrated into agricultural fields to reduce soil erosion and strengthen landscape functions. The framework combines conventional cost-benefit analysis with the ecosystem services concept to systematically identify, quantify, and, where possible, monetize the wider benefits generated by these interventions. Costs include implementation and maintenance expenditure as well as opportunity costs associated with foregone agricultural production. Benefits include avoided erosion-related damages and other ecosystem service improvements that can be incorporated according to data availability and the spatial scale of the assessment.

The framework was applied to alternative ETA scenarios across three agricultural locations. The scenarios differed in the spatial extent and configuration of grassed areas and linear erosion-control measures and were assessed against a baseline without ETAs over 15- and 25-year evaluation periods.

The results show that most evaluated scenarios generated positive net societal benefits, although their economic performance varied substantially across locations. Grassing the 20% of farmland with the steepest slopes generated the highest cumulative benefits and, in two locations, also the highest net present value. However, the scenarios with the highest benefit-cost efficiency differed among locations, while some more investment-intensive linear measures did not recover their societal costs within the evaluated periods.

The findings demonstrate that ecosystem service-based cost-benefit analysis can provide a practical framework for comparing alternative NBS configurations in agricultural landscapes. They also show that maximizing total societal benefits and maximizing benefits per unit of expenditure may lead to different choices, highlighting the importance of local biophysical and economic conditions when selecting and targeting NBS interventions.

Keywords: environmentally-technical areas, ecosystem services, cost-benefit analysis, soil erosion

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Model-Based Planning of Water Retention Measures in the Trierbach Catchment

Felix Zimmermann and Markus C. Casper

University of Trier, Germany

Abstract

Agricultural and forestry areas contribute significantly to rapid runoff generation due to soil crusting, compaction and dense artificial drainage systems. In steep headwater catchments, low-permeability road networks and drainage ditches accelerate the water transport, which exacerbates both flood discharge peaks and climate-induced drought stress. To mitigate these impacts a sustainable, climate-adapted water management strategy for agricultural and forestry landscapes with site-specific measures is required. These include terrain-adapted retention ditches (with or without plantings), road ditch diversions, ditch backfilling, infiltration trenches, and various forms of redistribution channels or decentralized retention basins. Addressing these challenges, this study focuses on the municipal area of Pomster, a typical headwater catchment in the Ahr Valley. It is characterized by a hydraulically “smooth” landscape dominated by flat plateau landscapes under agricultural management and extensive forest stands. These areas are directly connected to the Trierbach stream through steep gully systems, which leads to rapid runoff generation during extreme precipitation events.
As part of the project physical demonstration sites (“demonstrators”) will be constructed across both agricultural and forestry locations and equipped with hydrometric monitoring to evaluate their hydraulic and hydrological effectiveness. Furthermore, digital twins of the demonstrators will be developed to analyse the impact of decentralized retention measures at both local (e.g. municipal) and regional scale (e.g. the entire Ahr catchment). To ensure long-term usability of the results, the parameterization guidelines will be developed for the current modeling frameworks of Rhineland-Palatinate (HydroZwilling RLP and LARSIM), which enables realistic simulations of measure impacts across these different spatial scales. Methodologically, a hydrological model for the Kirmutscheid gauge catchment (Trierbach) is parameterized using the soil-hydrological map of Rhineland-Palatinate to identify critical runoff-generating process areas. In parallel, the LARSIM model will be adapted for comparative baseline modeling. For critical areas, high-resolution Digital Elevation Models (0.5 m grid) are modified to incorporate virtual retention measures. Their hydraulic efficiency is simulated using a 2D hydraulic model (HYDRO_AS 2D). Concurrently, the physical demonstrators will be surveyed alongside field measurements to quantify the retention efficiency of these measures. The resulting parameter adjustments serve to identify and characterize hydraulic alteration signals, which are integrated into LARSIM to refine its parameterization strategies.
Ultimately, the project delivers robust insights into the effectiveness of various water retention

measures based on coupled hydrological-hydraulic modeling, offering a tool to optimize measures prior to physical implementation. Furthermore, spatial assessments of water retention potential will provide actionable recommendations for agricultural and forest planning.

Keywords: water retention, 2D hydraulic simulation

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MuD CarboVino: Advancing Soil Carbon Sequestration and Resilience in German Viticulture

Mario Kirchhoff[1,*], Annegret Pflugfelder[2], Olympia Samara[3], Christian Ehrlich[2], Johannes Hoffmann[3], Nicole Weymann[1], Paul Swiderek[1] and Oskar Tag[4]

[1]*FAIR and GREEN e.V., Graurheindorfer Str. 92, 53117 Bonn, Germany, Germany*
[2]*Bioland Praxisforschung GmbH, Kaiserstr. 18, 55116 Mainz, Germany, Germany*
[3]*Demeter e.V., Brandschneise 1, 64295 Darmstadt, Germany, Germany*
[4]*ÖkoBeratungsgesellschaft mbH – Beratung für Naturland, Eichethof 1, 85411 Hohenkammer, Germany, Germany*

Abstract

Viticulture is an important component of German agriculture and cultural landscapes, but climate change is increasing the need for soils that are fertile, water-retentive and resilient. The model and demonstration project MuD CarboVino investigates practical strategies for maintaining and increasing soil organic matter and carbon sequestration in vineyards. Across 36 demonstration farms in the three selected wider regions Mosel, Pfalz/Rheinhessen/Nahe and Baden-Württemberg, the project combines scientific monitoring, agricultural advisory services and the experience of winegrowers in a transdisciplinary and participatory approach.
The participating farms include organic, biodynamic and conventionally managed sustainable vineyards. In collaboration with the farmers, five management strategies were selected: humus-promoting cover crops, biochar application, reduced tillage, sheep grazing and vitiforestry. Depending on the farm, these measures are implemented individually or in combination on defined treatment plots, each paired with a reference plot. The baseline survey conducted in spring 2025 included soil sampling at two depths (0–15 and 15–30 cm) and in different vineyard positions. Soil parameters comprised mineral nitrogen, organic carbon, soil organic matter, total nitrogen, C/N ratio, pH, texture, coarse fragments and bulk density. In the time of highest vegetation cover plant sampling of the vine leaves and cover crops was conducted. Annual monitoring will be complemented by economic assessments, stakeholder surveys, greenhouse-gas accounting and life-cycle assessment.
The initial survey demonstrates considerable variability in soil properties and farm conditions among the regions. Baden-Württemberg tended to show higher soil organic matter and mineral nitrogen values than the Mosel and Pfalz/Rheinhessen/Nahe sites. As expected, substantial changes in soil organic carbon cannot yet be assessed shortly after implementation; measurable effects are likely to emerge only over several years. The experimental design therefore provides a robust basis for distinguishing management effects from natural spatial and temporal variability and for calibrating process-based soil–plant–atmosphere models.
MuD CarboVino demonstrates how participatory, regionally differentiated management trials can support the development of climate-adapted and carbon-conscious strategies for perennial

cropping systems. The project will generate practical recommendations for viticulture, advisory services and policy while strengthening knowledge transfer between research and practice.

Keywords: Soil organic carbon, Humus formation, Climate-resilient viticulture, Cover cropping, Transdisciplinary research

AN5: Circular Nutrient Systems for Agricultural Transitions: Integrating Ecology, Governance, and Modelling

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Scaling Nature-Based Solutions Through Knowledge-Action Networks: Cooperation for Agricultural Transformation

Qirui Li

University of Hohenheim, Germany

Abstract

Nature-Based Solutions (NBS) are increasingly promoted as approaches for agricultural sustainability transitions because of their simultaneous support for biodiversity, soil restoration, nutrient retention, climate mitigation, and water quality improvement. Yet despite growing policy support and technical evidence, the scaling of NBS across European agricultural systems remains limited. This paper argues that the central barrier to NBS scaling is not primarily technological readiness or individual farmer behaviour, but systemic coordination and cooperation failure within agricultural socio-ecological systems (SES). Drawing on the Evolution of Cooperation (EoC) theory and Theory of Change (ToC), the paper attempts to explain how cooperation emerges, stabilises, and breaks down across experimentation, stabilisation, diffusion, and institutionalisation phases, through value-based, trust-based, reputation-based, network-embedded, and institutional cooperation. Comparative qualitative case studies are from Denmark, the Netherlands, Hungary, and the United Kingdom. The findings show that NBS scaling depends on whether different forms of cooperation become aligned across governance levels, markets, advisory systems, and rural actor networks. While shared stewardship values and trust-based learning enabled experimentation and stabilisation, scaling was frequently constrained by fragmented advisory systems, weak market incentives, regulatory incoherence, unequal access to knowledge-action networks, and unstable institutional support. Three cooperation-enabled transformation pathways are identified: regional nutrient circularity, biological substitution of synthetic inputs, and diversification through integrated landscape management. The study proposes a working hypothesis on sustainability transitions that scaling NBS is a coordination and cooperation problem rather than a simple adoption challenge for collective capacity to organise, stabilise, and govern knowledge-action networks, as suggested by the comparative European case studies.

Keywords: Nature-Based Solutions, socio-ecological systems, knowledge systems, collective action, evolution of cooperation, sustainability transitions

AN6: Biophysical Approach to Terroirs

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Biophysical Approach for Terroir Characterization: Evaluating Structural and Spectral Precision Via Consumer and RTK-Enabled UAVs in Vineyards

Jesús Rodrigo-Comino

University of Granada, Spain

Abstract

High-resolution biophysical monitoring is essential for understanding terroir dynamics and optimizing vineyard management under the framework of Nature-based Solutions (NbS). However, technical variability between Unmanned Aerial Vehicle (UAV) platforms poses challenges for the reproducibility of agronomic indicators. This study evaluates and compares the mapping and spectral performance of different UAVs over commercial European vineyards: e.g. a conventional consumer-grade model (Mavic 2 Zoom), a professional Real-Time Kinematic (RTK) enabled system (Mavic 3E RTK) and thermal camera (Matrice t4) . The geometric accuracy of Digital Surface Models (DSMs), effective spatial resolution, and the consistency of three RGB-based vegetation indices (ExG, VARI, and NGRDI) were systematically analyzed. The findings demonstrate that integrating RTK technology eliminates a systematic vertical bias of ~35 m inherent to conventional consumer sensors. After applying a robust Z-shift vertical correction, DSMs from both platforms showed high internal consistency, reducing the root mean square error (RMSE) to ~1.26 m. Furthermore, the RTK sensor provided a 20% higher effective spatial resolution, which is critical for fine canopy delineation. Regarding spectral data, normalized ratio indices (NGRDI and VARI) exhibited strong cross-platform robustness, whereas ExG showed high sensitivity to radiometric discrepancies. Ultimately, using normalized indices alongside vertical geometric harmonization enables reliable multi-temporal biophysical monitoring, providing a standardized workflow to accurately characterize crop structure and soil microclimates for strengthening NbS strategies in precision viticulture.

Keywords: UAV, RTK, vineyards, vegetation indexes

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From Soil Compaction to Erosion: How the Annual Crop Cycle Controls Infiltration and Runoff

Saskia Deborah Keesstra[1], Arfemi Cerdà[2], Diego Gámiz Monterde[3], Antonio Giménez Morera[4], Jesús Rodrigo Comino[5] and Jesús Barrena[6]

[1]*Wageningen University & Research, Netherlands*
[2]*Soil Erosion and Degradation Research Group. Department of Geography; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, Spain. artemio.cerda@uv.es,. 0000-0001-5326-4489, Spain*
[3]*Departamento de Economía y Ciencias Sociales, Escuela Politècnica Superior de Alcoy, Universidad Politècnica de Valencia. Plaza Ferrandiz y Carbonell s/n, 03801 Alcoy, Alicante, Spain., Spain*
[4]*Departamento de Análisis Geográfico Regional y Geografía Física, Facultad de Filosofía y Letras, Campus Universitario de Cartuja, Universidad de Granada, 18071 Granada, Spain., Spain*
[5]*Departamento de Geografía, Universidad de Valladolid, Spain, Spain*
[6]*Team Soil, Water and Land Use, Wageningen University and Research, Wageningen, the Netherlands, Netherlands*

Abstract

Annual cropping systems are dynamic environments in which soil properties and hydrological processes change substantially throughout the crop cycle (Lebon et al., 2003). Tillage, sowing, machinery traffic, crop development, harvesting and periods of bare soil can modify soil structure, bulk density, surface roughness, aggregate stability and vegetation cover, with important consequences for infiltration, runoff generation and soil erosion (Hamza & Anderson, 2005; Batey, 2009; Blanco-Canqui & Ruis, 2018). Understanding these temporal dynamics is essential for assessing soil degradation and designing more sustainable agricultural management strategies (Ruiz-Colmenero et al., 2011). This study examines how the different stages of the annual crop cycle influence soil compaction, infiltration capacity, runoff generation and soil erosion, with particular attention to the interactions between soil physical properties, agricultural operations and rainfall characteristics. Soil sampling, double-ring infiltrometer measurements and rainfall simulation experiments were conducted throughout 2013 in vineyards of the Celler del Roure winery, located in the eastern Iberian Peninsula and representative of Mediterranean vineyards where tillage is a major management practice. Measurements were carried out in February, April, June, August, October and December to capture temporal changes associated with agricultural operations and climatic conditions. Soil bulk density, infiltration rates, runoff generation and sediment delivery were determined for each sampling period. The results revealed marked seasonal variations in soil physical and hydrological properties throughout the agricultural year. Soil bulk density decreased from April to August following ploughing operations, when infiltration rates reached their highest values and runoff and soil erosion were lowest. These changes indicate that tillage temporarily modified soil structure and substantially affected the partitioning of rainfall

between infiltration and overland flow. However, the effects of agricultural operations were transient and strongly influenced by subsequent rainfall and soil conditions. The annual cycle was therefore controlled by the interaction between agricultural operations, soil physical conditions and climatic variability. Although numerous studies have investigated the effects of agricultural management on soil degradation, less attention has been paid to the temporal role of individual farming operations and their cumulative effects throughout the agricultural year (Darouich et al., 2022; Giffard et al., 2022). This is particularly relevant in vineyards, where seasonal operations such as tillage, harvesting and pest management repeatedly disturb the soil surface. Conservation agriculture, cover crops, residue management and reduced tillage can improve soil structure, enhance infiltration and reduce runoff and erosion, although their effectiveness depends on soil type, climate, crop rotation, management history and the timing of agricultural operations (Lal, 2004; Hobbs et al., 2008). Identifying critical periods of vulnerability can therefore provide a basis for targeted and preventive soil and water conservation measures, contributing to improved soil health, water regulation and the long-term sustainability of Mediterranean vineyard landscapes.

The annual crop production cycle involves a range of agricultural operations that disturb the soil and can substantially modify its physical properties, with subsequent effects on runoff generation and soil erosion. Although many studies have focused on the effects of soil management practices, relatively little attention has been paid to the role of individual agricultural operations carried out throughout the farming year in driving soil degradation (Darouich et al., 2022; Giffard et al., 2022). This issue is particularly relevant for crops requiring intensive seasonal management, such as vineyards, where tillage, harvesting and pest-control operations repeatedly modify soil conditions. The results showed marked seasonal changes in soil physical and hydrological conditions. Lower soil bulk density was observed from April to August following ploughing, coinciding with the highest infiltration rates and the lowest runoff and soil erosion rates.

Keywords: Soil, Erosion, Land, Terroir, Degradation, Agriculture, Water, Sediments

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Soil Erosion in European Vineyards: Current Knowledge, Management Challenges and Research Priorities

Jesús Rodrigo Comino[1], Jesús Barrena[2], Antonio Giménez Morera[3], Artemi Cerdà[4,*] and Diego Gámiz Monterde[5]

[1]*Departamento de Análisis Geográfico Regional y Geografía Física, Facultad de Filosofía y Letras, Campus Universitario de Cartuja, Universidad de Granada, 18071 Granada, Spain*
[2]*Departamento de Geografía, Universidad de Valladolid, Spain*
[3]*Departamento de Economía y Ciencias Sociales, Escuela Politècnica Superior de Alcoy, Universidad Politècnica de Valencia. Plaza Ferrandiz y Carbonell s/n, 03801 Alcoy, Alicante, Spain*
[4]*Soil Erosion and Degradation Research Group, Department of Geography, University of Valencia, Valencia, Spain. artemio.cerda@uv.es. 0000-0001-5326-4489, Spain*
[5]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, España., Spain*

Abstract

Soil erosion is one of the principal threats to the environmental and economic sustainability of European vineyards. Vineyards frequently occupy sloping terrain exposed to erosive rainfall, while conventional tillage, herbicide-maintained bare soil and machinery traffic reduce aggregate stability, infiltration and surface roughness (2005; Arnáez et al., 2007). Consequently, erosion rates often exceed soil-formation rates and tolerable soil-loss thresholds, particularly in Mediterranean vineyards, although substantial losses also occur in Atlantic, continental and Alpine regions (Panagos et al., 2015; Biddoccu et al., 2020). Reported values vary considerably according to rainfall erosivity, slope, lithology, vine-row orientation, plantation age, soil management and monitoring methodology (Rodrigo-Comino et al., 2016). Sediment export is accompanied by losses of organic carbon, nitrogen, phosphorus and agrochemicals, reducing soil fertility and affecting downstream water quality. The sustainable management of European vineyards involves balancing soil conservation, grape production, wine quality, economic viability and adaptation to climate change. This balance is particularly difficult because vineyards are perennial systems frequently established on sloping land, shallow soils or landscapes with considerable cultural value. Although management practices such as cover cropping, mulching, reduced tillage and buffer strips can substantially reduce erosion, their implementation is constrained by environmental variability, production objectives, labour requirements and farmers' perceptions of risk. These processes explain why conventionally managed vineyards often display high erosion rates, particularly where rows are oriented downslope (Arnáez et al., 2007; Rodrigo-Comino et al., 2016). Cover crops are among the most effective alternatives, but their management presents important difficulties. Permanent or temporary vegetation protects the soil from raindrop impact, increases surface roughness, traps sediment and improves aggregate stability. Root systems also promote soil

porosity and organic-carbon accumulation. Nevertheless, cover crops consume water, creating potential competition with grapevines in dry Mediterranean environments. This competition may reduce vine vigour, grape yield or berry size during drought. The challenge is therefore not simply to establish vegetation but to determine the appropriate species, density, spatial distribution and termination date. Temporary winter cover, alternate-row vegetation and early spring mowing may provide a compromise between soil protection and water conservation (Ruiz-Colmenero et al., 2013; López-Vicente et al., 2020).

The effectiveness of cover crops is strongly dependent on timing. Removing vegetation too early can leave the soil unprotected during erosive spring storms, while late termination may intensify competition during critical vine-development stages. Climate variability makes fixed calendars increasingly unreliable. Adaptive management based on soil moisture, weather forecasts, vine water status and cover-crop biomass is therefore required. However, such management demands technical knowledge, monitoring equipment and rapid access to machinery, which may be unavailable to small farms (Novara et al. 2011).

Mulching provides an alternative where competition for water is a major concern. Straw, chipped pruning residues and other organic materials protect the surface, reduce crust formation and contribute organic matter. Barley-straw mulch, for example, can rapidly reduce runoff and soil erodibility in Mediterranean vineyards. Nevertheless, obtaining, transporting and applying sufficient material may be costly. Mulches can be displaced by wind or runoff, interfere with vineyard operations and create concerns regarding fire risk, pests or disease. The origin and quality of the material must also be controlled to avoid introducing weed seeds, contaminants or pathogens.

Topography and vineyard design constitute another major challenge. Row orientation, slope length, terrace configuration and drainage networks strongly influence runoff concentration. Downslope rows facilitate mechanisation but act as preferential flow paths during storms. Contour planting can interrupt runoff, although it may be difficult or unsafe for machinery on steep slopes. Terraces reduce effective slope length but require careful maintenance.

Keywords: Terroir, Erosion, Soil, Vineyards, Agriculture, Europe

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AN7: Open session on Nature-Based Solutions in Agricultural and Natural Landscapes

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Regenerative Homestead Agroforestry for Restoration of Degraded Dryland: a Nature-Based Solution From Tribal India

Benukar Biswas

Bidhan Chandra Krishi Viswavidyalaya, India

Abstract

Monoculture farming reduces biodiversity, degrades soil, and weakens rural livelihoods. To address this, we tested a Regenerative Homestead Agroforestry (RHA) model with the Lodha tribal community in Jhargram, West Bengal, over eight years (2017-18 to 2024-15). The aim was to design a system-based integration of local need, ITK and ecological principle that is culturally acceptable, ecologically resilient, and economically viable. The RHA model combined multi-layer polyculture, companion crops that support mycorrhiza, no-till practices, and organic nutrient recycling. Livelihood options included beekeeping, poultry, and perennial crops. Social activities included school enrolment drives, arts-based training, documentation of Indigenous Technical Knowledge (ITK), and a community eco-tourism guesthouse. Annual monitoring recorded soil carbon, microbial activity, mycorrhizal colonization, pollinator diversity, school enrolment, income, and participation, compared with conventional farming, horticulture, and forestry. Soil organic carbon in RHA rose by over 25% in comparison to conventional farming. Microbial activity and earthworm density improved, and more than 80% of fruit trees showed mycorrhizal colonization. Pollinator diversity increased, improving crop yields. The RHA system produced 13.37 t ha^{-1} yr^{-1} of recyclable biomass and enhanced soil carbon, dehydrogenase activity, water-holding capacity, and biodiversity. Economically, it gave 5.6, 3.9-, and 2.1-times higher net present value than agriculture, forestry, and horticulture, respectively. Social outcomes included higher school enrolment, diversified household income, and more than 80% family participation in decision-making. The composite evaluation index demonstrated that RHA offers the highest level of multifunctionality of multiple ecosystem services. The RHA model shows that community-led agroforestry can restore ecosystems, reduce poverty, and strengthen cultural identity. It offers a scalable pathway for climate-resilient rural development and supports several SDGs.

Keywords: Regenerative agroforestry, tribal livelihoods, ecosystem services, multifunctionality, evaluation index

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A Catchment-Scale Digital Twin for Nature-Based Solutions: Integrating Hydrology, Indigenous Knowledge, and Customary Practices in Aotearoa New Zealand

John Reid, Matthew Wilson, Matthew Hughes, Maria Vega Corredor, Luke Parkinson and Martin Nguyen

University of Canterbury, New Zealand

Abstract

Nature-based solutions (NbS) are increasingly recognised as critical for enhancing climate resilience while delivering multiple economic, environmental and cultural co-benefits; although successful implementation is context dependent (Seddon et al., 2020; Chausson et al., 2020; Nesshöver et al., 2017). This paper presents the development and application of a catchment-scale environmental digital twin that integrates hydrological, land-use, and climate projection data to simulate how different wetland and forest ecosystem reconstruction scenarios influence flood attenuation within catchments in Aotearoa New Zealand. While digital twins are emerging as integrated, data-driven infrastructures for environmental modelling and decision support in water systems and hydrology (Ghorbani Bam et al., 2025), their application to NbS at a catchment scale is relatively new. Scenario modelling indicates that flood attenuation varies with both the extent and spatial configuration of reconstructed wetlands and forests. These findings are consistent with empirical studies that relate existing land-cover patterns to hydrological outcomes (NIWA 2024; Cooper et al., 2021; Dadson et al., 2017; Herath et al., 2025). An additional innovation of this work is the embedding of Indigenous knowledge and governance within the modelling framework through an ongoing partnership with Ngāi Tahu - the Indigenous people of Te Waipounamu (the South Island). The digital twin is not only a technical tool but also a platform for co-production of knowledge, supporting Indigenous-led environmental decision-making - an approach recognized for supporting equitable and legitimate outcomes (MacFarlane et. al., 2024; Bartlett et al., 2012; Tengö et al., 2014; Norström et al., 2020). In particular, the model incorporates methodologies (Townsend et. al., 2004) for representing mahinga kai abundance - customary food resources and harvesting practices - through the integration of local knowledge enabling holistic assessments of ecosystem health and cultural wellbeing. Beyond the focus on flood mitigation, the model will be progressively expanded to capture widely recognized additional co-benefits of NbS including: nitrate retention (Lyu et al., 2021; Hill, 2019; Land et al., 2016); biodiversity uplift (Rey Benayas et al., 2009; Crouzeilles et al., 2016); and carbon sequestration (Griscom et al., 2017; Xu et al., 2019; Pan et al., 2011), as well as costs associated with the loss of farm production landscapes (Miralles-Wilhelm 2023). By integrating these dimensions, the digital twin will, in time, provide a multi-criteria decision-support tool capable of evaluating trade-offs

and synergies across environmental, cultural, and economic objectives, which are recognized as important factors in the successful implementation of NbS at scale (Nesshöver et al., 2017; Albert et al., 2021).

Keywords: Nature-based solutions, digital twin, catchment-scale modelling, flood attenuation, ecosystem services, Indigenous knowledge, customary practices, co-production

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Nature-based Evolution: Traditional Ecological Practices in the Application of Blue-green Infrastructure for Climate Resilience

Vidya Anderson[1,*], William A. Gough[1] and Sarah Shujah[2]

[1]*Department of Physical & Environmental Sciences, University of Toronto Scarborough, Toronto, Ontario, CANADA, Canada*
[2]*Library Research & Digital Initiatives, University of Toronto Scarborough, Toronto, Ontario, CANADA, Canada*

Abstract

Climate hazards continue to escalate due to the impacts of a changing climate and pose a growing risk to both ecosystems and human populations. Urban resilience depends on the capacity of cities to respond to climate-related pressures such as rising temperatures, extreme flooding and food insecurity. Traditional ecological practices and historic blue-green infrastructure (BGI) can provide climate-proof strategies to increase urban climate resilience. This study evaluates the effectiveness of traditional BGI practices by mapping a common form of historical BGI – floating agricultural gardens – across geographies to examine 1) historic and contemporary functions in climate resilience, 2) modern challenges and threats to these heritage landscapes through Koppen analysis, 3) land cover and land use change observations, and 4) comparative analysis of site characteristics over time using archival maps and satellite imaging. Floating gardens are examined at seven locations on three continents and the impact of climate change on local floating garden climates is examined by using the time evolution of the Koppen climate classification for each location. Results of land cover and land use observation and the comparative analysis of site characteristics indicate urban encroachment is a significant threat to the viability and climate resilience of floating garden sites. This study is novel because it examines historic BGI in a contemporary context as a means of working with local landscape conditions to increase climate resilience and explores the synergies between floating garden agricultural practices across continents. Integration of traditional blue-green infrastructure practices in modern urban planning and design could provide a pathway forward.

Keywords: Nature-based solutions, floating gardens, floating agriculture, urban resilience, heritage landscapes

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Impacts of Land-use Diversity on Watershed Resilience: an Introduction to Hydrological Resilience

Viktoria E. Arnold, Björn Guse and Nicola Fohrer

Hydrology and Water Resources Management, Institute for Natural Resource Conservation, Kiel University, Germany

Abstract

Modern food systems have become increasingly homogeneous due to industrialization and globalization, leading to reduced resilience against environmental stressors and shocks. Within the interdisciplinary Research Training Group Diversilience (DIVERSification for Food Systems ResILIENCE), we explore how increasing land-use diversity, such as integrating flower strips and varied land-use patterns, affects watershed resilience. In this study we investigate how hydrological resilience can be defined and quantified at catchment scale. Grounded in the physical-hydrological framework of Newton & Spence (2023), we define hydrological resilience as a watershed's capacity to maintain its hydrological functions under climate and land-use change while remaining within its current regime. This definition combines resistance (the system's sensitivity to a stressor) and latitude (the possible range of recovery), focusing specifically on ecohydrological interactions between vegetation (crops) and the water cycle. We will establish an indicator framework spanning three primary hydrological functions: collection, storage (including vegetation storage), and release of water. To test this framework, the ecohydrological model SWAT+ will be applied to a Northern Germany catchment (Kielstau river) to simulate the effects of diversified land-use scenarios on different hydrological components. This research aims to develop a robust indicator set to quantify ecohydrological resilience and identify how land-use diversification can strengthen watershed capacity against environmental changes.

Keywords: hydrological resilience, land-use diversity, land-use change

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NbS Rapid Assessment (Ras): Maximum Impact Operationalising the Iucn Global Standard for Landscape Restoration

Irene Morell Rodríguez[1,2,*], Sara Peláez-Sánchez[3] and Pilar Gegúndez[4]

[1]*Member of the Commission on Ecosystem Management of IUCN Universidad Europea de Madrid, Faculty of Medicine, Health and Sports, Calle Tajo s/n, 28670, Villaviciosa de Odón, Madrid, Spain., Spain*
[2]*Universidad Europea de Madrid, Faculty of Medicine, Health and Sports, Calle Tajo s/n, 28670, Villaviciosa de Odón, Madrid, Spain*
[3]*Cámara de Comercio Zamora, Av. Feria 10. 49031, Zamora., Spain*
[4]*3Department of Sustainability, Holcim, Av. Manoteras 20, 28050 Madrid, Spain*

Abstract

Breaching critical planetary boundaries has intensified land degradation worldwide, calling for rigorous, evidence-based approaches to regain ecological integrity and foster resilient communities. Restoration projects lacking standardised design are at higher risk of long-term failure, offering fragmented intervention rather than lasting ecosystem recovery. This preliminary study introduces the NbS Rapid Assessment (RAS), serving as a rapid diagnostic check to rigorously vet project concepts, identify critical operational baselines, and assess compliance with the IUCN Global Standard for Nature-based Solutions™ (IUCN GS NbS). Rather than replacing full-scale planning, this rapid diagnostic tool provides vital guidance and tailored recommendations to optimise project design before large-scale execution and identify breaches to ensure solutions remain sustainable over time. Its efficacy is tested across three Spanish case studies transitioning degraded territories into functional natural infrastructure. In La Veguilla Crypto-wetland (Toledo), a sensitive temporary Mediterranean wetland lacking permanent surface water, RAS guided hydrogeological characterisation and biofiltration restoration following extreme rainfall (the September 2023 DANA) and associated post-flood contamination risks, supporting ecosystem services such as flood buffering and aquifer recharge. Ongoing work includes creating a climate shelter to propagate endemic protected species (e.g., Sisymbrium cavanillesianum, Limonium toletanum) while integrating community-oriented educational and recreational spaces within a peri-urban landscape. In the Cañada Real Conquense Corridor, RAS supported the use of the IUCN Standard to scale a local intervention into a regional ecological corridor, reviving traditional transhumance routes that enhance seed dispersal, soil fertility, rural livelihoods, pastoral heritage, plus an active work on fire prevention. Critically, the RAS identified the need for a context-adapted biodiversity and connectivity monitoring framework as the most critical gap for the NbS design phase. In La Chanta Quarry-Wetland, RAS evaluated the transformation of a former limestone quarry into a protected wetland addressing land degradation and water scarcity, confirming its role as a biodiversity stepping-stone in an arid landscape while highlighting the need for long-term

funding and stronger integration into regional spatial planning. Across all cases, the RAS proved effective as a rapid diagnostic filter, surfacing not only the strengths of each intervention but also the specific, closeable gaps (financial sustainability, governance protocols, adaptive management and monitoring design) that must still be resolved for these projects to qualify as genuine, high-performing Nature-based Solutions under the IUCN Standard. Embedding these recommendations ensures isolated interventions successfully evolve into self-sustaining, high-performing ecological networks delivering measurable benefits for climate adaptation, biodiversity connectivity, cultural heritage endurance and human well-being.

Keywords: Nature-based Solutions, Rapid Assessment, IUCN Global Standard, Crypto wetland, Transhumance and Quarry-Wetland

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NH1: Fire in the Earth System. Understanding fire and society

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A Proposed Framework for Multi-temporal UAV-based Analysis of Post-wildfire Agroecosystem Recovery in Mediterranean Vineyards Using Object-based Classification

Sebastian Löblein[1], María Teresa González-Moreno[2], Christos Xouris[3] and Jesús Rodrigo-Comino[2,*]

[1]*University of Leipzig, Leipzig, 04109, Germany*
[2]*Departamento de Análisis Geográfico Regional y Geografía Física, Andalusian Research Institute in Data Science and Computational Intelligence, DaSCI, University of Granada, 18071, Granada, Spain*
[3]*Gaia Robotics IKE, 10 Odyssea Elyti, Patras, 25002, Greece*

Abstract

Mediterranean agroecosystems are increasingly exposed to the effects of climate change and recurrent wildfire events, which can severely alter vegetation structure, crop condition, and land cover dynamics. In vineyard landscapes, post-fire monitoring is needed not only to describe recovery processes, but also to identify which land cover types are most vulnerable, which recover faster, and how spatial configuration influences fire propagation. This ongoing study proposes a methodological framework to investigate post-wildfire dynamics in a vineyard area near Patras, Greece, using multi-temporal unmanned aerial vehicle (UAV) imagery acquired between August 2025 and February 2026. The aerial surveys were conducted with a DJI Mavic 3 Enterprise drone, providing ultra-high-resolution RGB imagery with a Ground Sampling Distance (GSD) ranging from 1.5 to 2.5 cm per pixel. Orthomosaics and surface models were generated through photogrammetric processing, using Pix4Dmapper for the first two campaigns and ArcGIS Drone2Map for the subsequent acquisitions. Covering the period immediately after the fire and the first stages of recovery, the study site includes vineyards, olive trees, bare soil, and burned surfaces, providing a heterogeneous Mediterranean test area for analysing class-specific fire effects and regeneration patterns. To ensure temporal comparability, all RGB orthomosaics were co-registered using the AROSICS framework, allowing a pixel-consistent analysis across acquisition dates. Subsequently, an object-based workflow will be applied to segment the imagery into meaningful polygons and classify the first post-fire scene into the main land cover classes: vine, burned vine, olive trees, soil/ground, and burned area. This classification will provide the basis for tracking temporal trajectories of each class and for comparing their spectral and structural responses during the recovery period. Recovery will be assessed using RGB-based vegetation indices, including Excess Green (ExG), Visible Atmospherically Resistant Index (VARI), and Normalised Green-Red Difference Index (NGRDI), together with structural information derived from the digital surface model. By approximating a digital terrain model (DTM) through morphological filtering, a canopy height model (CHM) will be generated to complement the analysis with information on vegetation

structure. Beyond temporal monitoring, the framework aims to analyse how the location and spatial arrangement of land cover entities may have influenced the wildfire impact, identifying highly vulnerable zones where the fire spread unhindered versus areas where specific vegetation structures or land management acted as natural firebreaks. Ultimately, the proposed approach combines high-resolution UAV remote sensing, object-based image analysis, and multi-temporal indicators to assess both post-fire recovery and spatial vulnerability in Mediterranean agricultural landscapes. It contributes to TerraEnvision themes related to natural hazards, climate-resilient land management, and methods to measure environmental processes through remote sensing and deep learning applications.

Keywords: UAV remote sensing, wildfire recovery, object-based image analysis, RGB vegetation indices, Mediterranean agroecosystems, vineyards, UAV high-resolution landcover classification

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Like Water and Fire

Bertram de Rooij

Wageningen Environmental Research, Droevendaalsesteeg3 6700PB, Wageningen, The Netherlands

Abstract

This summer Europe is once again confronted with the impact of climate change. This impact cannot be seen without the linkages with land use, society and economy. The current state, choices made in the past and current developments exacerbate the situation the continent is facing. Wetter winters, prolonged droughts, massive wildfires and extreme weather in terms of concurrent and sequential heatwaves and torrential rains, set the continent for an immediate challenge. While climate mitigation remains key, climate adaptation should be fore fronted in all our decisions. In this adaptation journey natural systems and Nature-based Solutions are pivotal. Recent research outlined Europe does not face a major shortage of Nature-based Solutions or policy ambitions, instead it misses vision, mainstreaming adaptation and, most of all, full-fledged implementation (Parveen et al, 2026; Van Hattum et al, 2023).
Like water and fire, will move from the fire front to the design table and takes the participants along current insights and pressing needs to bridge single solutions to integrative and cross-sectoral perspectives and implementation. Looking back at the severe season of 2025, drawing on current insights from recent major events and bringing in practical experiences from running projects within the framework of the EU Mission on Adaptation to Climate Change, like NBracer and DesirMED. How can we navigate from inspirational desired futures and vision to immediate action and implementation across sectors without losing time? How can we tune in to the max to contextual differences and interdependencies from a systemic and multiscalar perspective? What are enabling and hindering factors and how to unlock these in the short-term to work towards a resilient and prosperous future?

Keywords: Landscape approach, fuel management, fire management

NH2: Flood Recovery - Interdisciplinary Perspectives into Post-Disaster Governance

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A GIS-Based Planning Workflow for Flood Adaptation and Land Policy in the Araklı District

Fatih Terzi[1], Bura Adem Atasoy[2,*] and Yasin Demir[3]

[1]*Karadeniz Technical University, Graduate School of Natural and Applied Sciences, Trabzon, 61080, Türkiye*
[2]*Karadeniz Technical University, Department of Geomatics Engineering, Trabzon, 61080, Türkiye*
[3]*Erzurum Technical University, Department of Electrical and Electronic Engineering, Erzurum, 25050, Türkiye*

Abstract

Flood-prone settlements require planning approaches that can connect risk evidence with land-use decisions, property rights, and feasible policy instruments. This issue becomes more visible where private parcels are located in areas in which future development may need to be limited for public safety, climate adaptation, and nature-compatible land management. This contribution focuses on the Araklı district of Trabzon, Türkiye, where a severe flood occurred in 2019. It proposes a GIS-based planning workflow to discuss how flood-related spatial evidence could support policy decisions on risk-sensitive urban development and property-right arrangements. The proposed workflow would begin with the identification of flood-affected and flood-susceptible areas. Satellite images, including Sentinel-1 SAR data, topographic information, and existing GIS layers would be used to derive an initial flood footprint and support susceptibility analysis. These outputs would be treated as preliminary spatial evidence and would need to be checked through accuracy assessment, visual interpretation, local knowledge, and available reference information before any parcel-level interpretation. The main policy concern is how flood-related constraints could be translated into fair and implementable planning decisions. Refined flood outputs would therefore be evaluated together with cadastral parcels, land-use data, planning layers, buildings, infrastructure, and ownership information. This spatial evaluation is intended to identify parcels where development restrictions may be required and to clarify whether these areas may need urgent intervention, long-term planning control, or a combined approach. Restricted flood-risk areas would also be considered as possible spaces for nature-based solutions, green infrastructure, and flood attenuation functions. This perspective would connect property-right reconfiguration with wider adaptation agendas, including sustainable urban planning and resilient land-use systems. Value-based land readjustment, transfer of development rights, land exchange, public acquisition, and compensation are discussed as possible policy tools. Particular attention is given to two options: transferring development rights while ownership remains in place, or transferring both ownership and development rights where public safety, environmental sensitivity, or future land-use decisions require stronger intervention. Receiving areas could be assessed through 3D urban modelling to estimate possible effects on density, building mass,

infrastructure demand, and urban form. The proposal seeks to connect flood evidence with spatial restrictions, compensation options, and planned urban growth within a common framework. Although developed around the Araklı pilot area, the workflow may also support discussion on how flood-prone settlements can reduce risk in vulnerable areas while addressing property rights, development pressure, and sustainable land-use transitions.

Keywords: Flood adaptation, GIS, land policy, property rights, sustainable urban planning

NH3: Open session on Nature-Based Solutions for Natural Hazard Mitigation

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Evaluating Sponge Measures' Effectiveness in Mitigating Flood Extremes at Littlestock Brook, Upper Thames, Uk

Neeraj Sah, Vasilis Myrgiotis, Burak Bulut, Adriana Calderon, James Blake, Amulya Chevuturi and Alejandro Dussaillant

UK Centre for Ecology & Hydrology, United Kingdom

Abstract

Evidence on the effectiveness of sponge measures in mitigating flood extremes continues to grow, but relatively few sites combine catchment-scale storage features, paired land-use soil monitoring, soil hydraulic characterisation, satellite-based Earth Observation (EO) and event-based hydrological response in one place. We present initial findings from Littlestock Brook (16 km^2, Upper Thames, UK), a SpongeScapes case study where about 60 sponge measures — leaky woody dams, field-corner bunds, online and offline storage, swales and new woodland — have been installed since 2017 as part of the Evenlode Natural Flood Management (NFM) project. The NFM features occupy less than 1% of the catchment yet drains around 44% of the upper sub-catchments.

We draw on monitoring strands from 2024 to 2026: storm-event response from nine in-stream and pond sensors during the 23 September 2024 event, 'Storm Bert' on 24 November 2024, and the consecutive wet sequence of November 2025 to February 2026, contrasting similar rainfall totals on dry versus wet soils; paired soil moisture profiles under arable and adjacent new woodland; monitored measurements of porosity and saturated and unsaturated hydraulic conductivity under different land uses in 2024 and 2025; and initial HEC-RAS 1D–2D modelling of downstream flood response under different events and antecedent conditions.

As a complementary, independent line of evidence, the SpongeWorks project applied a satellite-based Earth Observation (EO) assessment over Littlestock Brook, using Sentinel-2 NDWI and Sentinel-1 SAR water mask to test whether space-based retrieval can detect water retention driven by sponge measures. For Storm Bert, no clear inundation signal was detected in the main downstream area of interest, but clear evidence of water retention was found within upstream sponge measures, suggesting these were activated during the event even though the target reach itself showed no observable inundation. Robust attribution to the sponge measures remains limited by the small number of comparable extreme events analysed so far.

Together, the monitored and EO strands span surface, sub-surface, feature-scale and catchment-scale responses at a single well-instrumented site, and illustrate both the value and the current limits of combining monitored and satellite EO data to inform design, monitoring and maintenance assumptions for sponge measures in similar lowland catchments.

Keywords: Flood extremes, catchment monitoring, Sponge measures, Satellite Earth Observation,

SpongeScapes, SpongeWorks

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Simulation of Water Retention Measures in Forests: a Comparison of Model Approaches

Moritz M. Heuer and Markus C. Casper

University of Trier, Germany

Abstract

Climate change is causing longer periods of drought while it also leads to an increase in heavy rainfall events. As a result, efforts are necessary to increase water retention on both agricultural and forested lands. To examine the effectiveness of such measures, two models were developed and compared for a small forest watershed in northern Rhineland-Palatinate. One model is based on the HydroAS hydraulic model and is suitable for simulating surface runoff, while the other model is based on Hydrozwilling, which can also account for aspects of infiltration and interception. Water retention measures such as sheet pile walls, roadside drainage, swales, and other retention structures were incorporated into the models. A precipitation event was then simulated, and the resulting runoff was compared between the baseline condition and the condition after implementing the measures. By combining these measures, a larger proportion of the runoff can be retained and the discharge in the channel reduced, which has a positive effect on water retention and flood protection. Also, pronounced differences between both models can be seen which can be attributed to the differences in the underlying conceptual models.

Keywords: water retention, hydraulic simulation

NH4: Success Factors in Wetland Restoration for Enhancing Natural Water Retention Capacity

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Assessing Policy Instruments for Wetland Restoration: Insights From Stakeholder Interviews Across Europe

Lenka Zaňková, Jan Macháč, Lenka Slavíková and Jan Brabec

Faculty of Social and Economic Studies, Jan Evangelista Purkyně University in Ústí nad Labem, Czechia

Abstract

Ecosystem restoration, particularly wetland restoration, plays a key role in enhancing landscape “sponge functions” that support water retention, flood risk reduction, and climate resilience. While European policy frameworks increasingly emphasise scaling up restoration through innovative governance and financing mechanisms, less attention has been paid to how these instruments are perceived by stakeholders involved in their implementation. This contribution examines stakeholder-based assessments of selected policy and market-based instruments supporting wetland restoration across several European case studies. Drawing on semi-structured interviews with landowners, public authorities, NGOs, and practitioners, it explores four types of instruments (voluntary agreements, payments for ecosystem services, biodiversity and carbon offsets, and flood risk pooling schemes) and how they are evaluated in practice. The analysis focuses on four key criteria: environmental effectiveness, cost-efficiency, political feasibility and legitimacy, and equity in the distribution of costs and benefits. It also considers contextual factors shaping these evaluations, such as institutional settings, trust, and stakeholder capacity. The findings reveal differences in perceptions across actor groups and contexts, highlighting key enabling conditions and barriers to wider adoption. They point to trade-offs between efficiency and legitimacy, as well as challenges related to fairness and long-term commitment. By linking stakeholder perspectives with policy design, this study provides insights into how governance and financing mechanisms can be better tailored to local contexts. It contributes to debates on scaling up wetland restoration in Europe by identifying pathways towards more effective, legitimate, and equitable implementation of nature-based solutions.

Keywords: Wetland restoration, Policy instrument, Stakeholder perspectives, Innovative financing

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Assessing Wetland Restoration Effects on Natural Water Retention: Initial Hydrological Modelling Results From the Schneifel Case Study

Philip Meier

Lehrstuhl und Institut für Wasserbau und Wasserwirtschaft Institute of Hydraulic Engineering and Water Resources Management RWTH Aachen University Mies-van-der-Rohe-Straße 17 D-52074 Aachen Germany, Germany

Abstract

Wetland restoration is increasingly promoted as a nature-based solution to improve natural water retention, reduce runoff peaks, and enhance ecosystem resilience. However, quantifying the hydrological effects of restoration measures remains challenging, especially in small headwater catchments where long-term monitoring datasets are often limited. This contribution presents the modelling approach and first intermediate results from the Schneifel case study in western Germany, which is part of the Horizon Europe project SpongeBoost. The study area is a forested ridge landscape with high rainfall, waterlogged clay-schist soils, and valuable fen, wet heath, and wet forest habitats. Restoration measures include the removal of non-native spruce and the blocking of drainage ditches to support a more natural water regime and improve water retention.

To assess the hydrological effects of these interventions, a hydrological model of the catchment is being developed and linked with new field monitoring data. Since early 2026, discharge-related observations at the outlet have been recorded continuously using water level and flow velocity measurements, while precipitation input is derived from a nearby German Weather Service station. Additional soil-moisture monitoring is being integrated into the monitoring concept to improve process understanding and future model calibration. The modelling framework combines monitoring-based calibration with scenario analysis to compare degraded, restored, and more natural catchment states. Initial results focus on the methodological setup, first calibration steps, and the derivation of indicators for sponge potential and runoff retention.

The contribution highlights both the opportunities and limitations of modelling restoration effects under still-developing data availability. It further discusses how intermediate modelling results can already support the evaluation of wetland restoration measures aimed at strengthening natural water retention capacity and improving the hydrological functioning of restored headwater landscapes. The contribution directly addresses the conference session “Success Factors in Wetland Restoration for Enhancing Natural Water Retention Capacity.”

Keywords: wetland restoration, natural water retention, hydrological modelling, headwater catchment, SpongeBoost

UR1: Decentralised Urban Water Systems for Circularity

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Green4Grey: Advancing Urban Water Circularity Through Decentralized Nature-Based Solutions

Ioannis Louloudakis, Ioannis N. Daliakopoulos, Dimitrios Papadimitriou, Katerina Katrini and Thrassyvoulos Manios

Hellenic Mediterranean University, Department of Agriculture, Heraklion, Greece

Abstract

Urban areas are increasingly challenged by water scarcity, climate variability, and growing pressure on freshwater resources. At the same time, significant volumes of non-conventional water resources, including greywater, rainwater, and urban runoff, remain underutilized despite their potential contribution to more circular and resilient urban water systems. The adoption of decentralized water reuse solutions is often hindered by technical, environmental, regulatory, and social barriers, highlighting the need for integrated approaches that can demonstrate both safety and effectiveness.

The Green4Grey project aims to enhance urban water circularity through the development and validation of decentralized Nature-Based Solutions (NbS) that safely treat, monitor, and reuse non-conventional water resources within urban environments. The project combines green infrastructure, environmental monitoring, digital tools like City Information Model, risk assessment frameworks, and stakeholder engagement to support the transition towards sustainable and resilient urban water management.

Green4Grey brings together complementary pilot systems in Greece, Israel, Czechia, Spain, and Brazil, showcasing different approaches to water reuse and green infrastructure integration. These include greywater reuse systems, rainwater harvesting technologies, green roofs, constructed wetlands, urban runoff management solutions, and digital monitoring platforms. The pilots provide a diverse testing environment for evaluating system performance, resource efficiency, environmental safety, and operational reliability under different climatic and urban conditions.

Expected outcomes include validated pilot applications, monitoring and decision-support tools, risk assessment and mitigation strategies, spatial planning frameworks, and practical guidance for the wider implementation of decentralized water reuse systems. By generating transferable knowledge and demonstrating innovative NbS solutions across multiple international case studies, Green4Grey seeks to support cities, practitioners, and policy makers in accelerating the transition towards climate-resilient and circular urban water systems.

Keywords: Nature-Based Solutions, Urban Water Circularity, Greywater Reuse, Decentralized Water Systems, Green Infrastructure, Climate Resilience, Water Reuse

Acknowledgments: The presenter acknowledges financial support from COST Action CA23104

'Water4Reuse – Mainstreaming water reuse into the circular economy paradigm' for attending and presenting at this conference.

UR2: Greening Cities for Climate Action: Resilience, Mitigation, and Community Well-Being

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Quantifying Ecosystem Services of Urban Community Gardens Using InVEST: Implications for Nature-based Solutions in New York City

Calista Hughes and Dr. Gaston Small

University of St. Thomas, United States

Abstract

Urban community gardens are widely recognised as nature-based solutions (NBS) that enhance food access, social cohesion, and urban biodiversity. However, their contributions to key ecosystem services—particularly those related to urban climate regulation and water management—are rarely quantified in ways that inform planning and investment decisions.
We apply the InVEST modelling framework to evaluate ecosystem services provided by community gardens across two council districts in New York City. The analysis focuses on gardens participating in the GreenThumb program, which supports more than 500 community-managed sites distributed across highly developed urban landscapes. This project specifically focused on two council districts with changing political personnel and goals. Spatial datasets describing garden extent and land cover were integrated with publicly available land-use/land-cover data to generate model-ready inputs. We classified gardens into one of four different categories, based on tree canopy cover and impervious surface within the garden footprint.
We developed spatial scenarios comparing current conditions, with gardens across the urban landscape, to a hypothetical scenario where gardens were replaced with paved surfaces. These scenarios were used to parameterise the InVEST Carbon Storage and Sequestration, Urban Cooling, and Urban Stormwater Retention models to estimate the marginal contributions of community gardens to carbon storage, urban heat mitigation, and stormwater retention.
In addition to quantifying ecosystem service provision, this work evaluates methodological challenges associated with representing small, heterogeneous green spaces in land-use/land-cover datasets and ecosystem service models. In particular, we assess how classification resolution and parameterisation influence modelled outcomes for dispersed, parcel-scale NBS features.
This study demonstrates how spatially explicit modelling can be used to quantify and communicate the environmental benefits of community gardens, supporting urban planning, climate resilience strategies, and evidence-based investment in distributed green infrastructure.

Keywords: urban community gardens, climate resilience, spatial modelling

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Climate-Induced Displacement and Labour Migration From Somalia: Governance Gaps in Drought and Flood-Driven Mobility.

Yusuf Mohamed Adan

Federal Parliament Of Somalia, Somalia

Abstract

Somalia does not experience climate change as an abstract threat. Recurrent droughts and seasonal flooding — particularly across the Shabelle and Juba river basins — have become the primary engine of population displacement, pushing millions into irregular mobility long before formal labour systems can respond. The 2021-2022,2023-2024 drought, the worst in four decades, did not simply kill livestock and crops. It emptied villages.

What follows displacement matters as much as the displacement itself. Somali workers move — toward Gulf states, toward Yemen, toward uncertain corridors — without legal status, without bilateral protection, and without any mechanism that acknowledges why they left. Existing governance frameworks treat them as economic migrants. They are often something more complicated: people displaced by environmental collapse who need work to survive and to send money home.

Between 2022 and 2025, as Minister of Labour and Social Affairs, I negotiated Somalia's Bilateral Labour Agreement (BLA) with the Kingdom of Saudi Arabia, finalised in December 2024. It is a meaningful step. But I am aware of what it does not contain. There is no clause that responds to climate shock — no provision that activates enhanced protections when drought or flooding triggers a surge in outward mobility. That gap was not an oversight unique to Somalia. It reflects a broader failure to connect climate adaptation thinking with bilateral labour diplomacy.

This paper proposes that sending states facing recurrent climate shocks need a different kind of agreement architecture — one where declared environmental emergencies trigger specific worker protections, expedited documentation, and return guarantees. I draw on comparison with Ethiopia's drought-response migration policies and the Philippines' climate-mobility frameworks, neither of which is perfect, but both of which take the connection seriously.

Managed labour migration, in Somalia's context, functions as a de facto climate resilience mechanism. Remittances stabilise households that have lost everything to flood or drought. That reality deserves explicit recognition in the governance structures we build — not as an afterthought, but as a design principle.

Keywords: Climate displacement, labour migration, drought resilience, fragile states, Horn of Africa

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Insights Into Climate Change Dynamics: a Tourism Climate Index-based Evaluation of Gilgit-Baltistan, Pakistan

NADEEM ULLAH

School of Architecture, Tianjin University, Tianjin, China

Abstract

Background: Tourism is a vital economic sector in Pakistan, yet the country is highly vulnerable to climate change. Gilgit-Baltistan, a major tourist destination in the Himalayan region, faces changing climatic conditions that affect tourist comfort and destination viability. However, limited research has quantitatively assessed climate change impacts on tourism in this region.
Objective: This study applies the Tourism Climate Index (TCI) to evaluate the current and future suitability of climatic conditions for tourism in six key locations of Gilgit-Baltistan (Astore, Bunji, Chillas, Gilgit, Gupis, and Skardu). It also projects TCI changes under three Shared Socioeconomic Pathways (SSP126, SSP370, SSP585) using three climate models.
Methods: TCI was calculated based on five sub-indices: daytime comfort (CID), daily comfort (CIA), precipitation (R), sunshine hours (S), and wind speed (W). Historical climate data (1991–2021) were obtained from the Pakistan Meteorological Department and ERA5 reanalysis. Future projections (up to 2085) were derived from CHELSA 2.1 data using three climate models. Bias correction and regression imputation were applied for missing variables.
Results: Currently, most stations show “excellent” TCI ratings in summer (May–October), with Gilgit and Gupis maintaining favourable conditions for up to six months. Under optimistic scenarios (SSP126), TCI remains stable or slightly improves. Under pessimistic scenarios (SSP370, SSP585), summer TCI declines due to projected temperature rises, shifting peak comfort to spring and autumn. Astore shows the highest resilience, while Chillas and Bunji experience increased summer discomfort. TCI never falls below “acceptable” in any scenario.
Conclusion: Climate change will alter the seasonality of tourism comfort in Gilgit-Baltistan, but the region remains a viable tourist destination for the coming century. Sustainable tourism planning must incorporate climate adaptation strategies. The TCI proves effective for assessing climate–tourism dynamics and can be extended to other regions of Pakistan.

Keywords: Climate Change, Tourism Climate Index (TCI), Sustainable Tourism, Gilgit-Baltistan, Climate Adaptation, Tourism Planning, Shared Socioeconomic Pathways (SSPs), Bioclimatology

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Concept for Climate Change Adaptation in the Trier-Saarburg District (Germany)

Feras Youssef[1,*], Thomas Iserloh[1] and Karsten Wilhelm[2]

[1]*Environmental Department; District Administration Trier-Saarburg; Willy-Brandt-Platz 1, 54290 Trier, Germany*
[2]*Institute for Applied Material Flow Management (IfaS), Trier University of Applied Sciences, Environmental Campus Birkenfeld, Campusallee, 55768 Hoppstädten-Weiersbach, Germany*

Abstract

The impacts of climate change can be observed worldwide and are also clearly visible in the District of Trier-Saarburg. In recent decades, the region has experienced a significant increase in the number of hot days, a decline in ice and frost days, and a growing frequency of heavy rainfall events. These developments pose considerable challenges to the environment, infrastructure, public health, and overall quality of life.
Recognizing these challenges and their implications for local communities, the Trier-Saarburg District Administration has taken proactive steps in both climate mitigation and climate adaptation. Within this framework, and with the support of the Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety (BMUKN), a climate adaptation project was launched in June 2025.
The objective of the project is to develop a comprehensive climate adaptation concept to identify suitable measures to reduce future climate-related risks and enhance the quality of life for residents.
The project is being implemented by the District Administration of Trier-Saarburg, which has commissioned the Institute for Applied Material Flow Management (IfaS) as an implementing partner.
The aim of this presentation is to illustrate the impacts of climate change on the District of Trier-Saarburg and to present the progress made in developing the regional climate adaptation concept, which is scheduled for completion in 2027.

Keywords: climate change, Adaptation strategy, nature-based solutions, Trier-Saarburg

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Nature-based Solutions as a Bridge Between Human Health and Climate Adaptive Cities

Joyce Zwartkruis

Wageningen University and Research, Netherlands

Abstract

The interconnected and interdependent connection between human health and a healthy environment is becoming increasingly clear (EEA, 2026). In the field of One health research, which is originally mainly focused on preventing zoonotic risks, the World Health Organization (WHO), World Organisation for Animal Health (WOAH), Food and Agriculture Organisation of the United Nations (FAO) and United Nations Environment Programme (UNEP) recently emphasized that they would like to integrate the environment more into the One Health approach (WHO, WOAH, FAO and UNEP, 2026). So far, Nature-based solutions (NbS) originate from goals related to climate adaptation or improving biodiversity, while the co-benefits, such as improving health, are increasingly getting more attention (WHO, 2025). However, it is still not easy to bridge the gap between human health and NbS in practice, especially in cities where pressure on space is increasing rapidly. When looking at NbS as practical interventions to improve One Health goals, they become more integrated. In our research we bring these perspectives together by looking at Nature-based solutions and the role they can fulfil in the Nexus between biodiversity, climate, water, and health. The point at which these two promising pathways, NbS and One Health, come together is at the design and maintenance of the NbS. By designing NbS in such a way they do not only improve biodiversity and climate adaptation but provide health benefits as well, the role of NbS in society can grow. If NbS are positioned as a bridge between human health and healthy environments (WHO & IUCN, 2023), NbS can strengthen synergies between both domains and thereby lead to a more efficient use of limited space and resources and a more attractive narrative. Especially in times where people are getting less connected with nature (Richardson, 2025), the number of people living in urban areas is growing and space for nature in cities is limited, it is becoming more important to make smart choices on how to fulfil as many functions as possible on one spot. NbS can substantially add to the solution of this complex puzzle, if policy, resources and knowledge are in place as well.

Keywords: Nature-based Solutions, Health, Cities

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Field Monitoring of Plant Functional Traits and Thermo-hydric Behaviour to Assess the Multifunctionality of Urban Nature-based Solutions

Amrita Mukherjee[1,*], Marc Saudreau[2], David Ramier[3], Nicoleta Schiopu[4], Rémy Claverie[5], Jérémy Thiriat[5] and Didier Techer[5]

[1]*TEAM, Cerema, 54510 Tomblaine, France, Université Clermont Auvergne, INRAE, UMR PIAF, 63170 Aubière, France*
[2]*Université Clermont Auvergne, INRAE, UMR PIAF, 63170 Aubière, France*
[3]*TEAM, Cerema, 78197 Trappes, France*
[4]*CSTB – 38400 Saint-Martin-d'Hères, France*
[5]*TEAM, Cerema, 54510 Tomblaine, France*

Abstract

Nature-based Solutions (NbS) are increasingly implemented to mitigate urban heat islands, improve stormwater regulation, and enhance climate resilience in cities. However, assessing the multifunctionality of vegetation remains challenging due to plant functional diversity, complex interactions in the soil–plant–atmosphere continuum (SPAC), and the spatial heterogeneity of urban environments. Field-based monitoring approaches linking plant functional traits, thermo-hydric behaviour and ecosystem service delivery remain limited in urban contexts.
This study presents the experimental setup and integrated monitoring framework developed within the ANR PENATE project to assess the thermo-hydric functioning of urban vegetation. The framework is implemented across different NbS typologies, including two renatured schoolyards, urban stormwater trees and a green roof. The approach combines field monitoring and process-based modelling through a sensor network deployed across pilot sites in Strasbourg and Les Mureaux (France).
The monitoring strategy combines multi-scale measurements to characterise water and energy fluxes within the SPAC, including soil moisture and matric potential, tree sap flow, dendrometric variation, surface temperature, and meteorological and microclimatic conditions. This dataset is complemented by measurements of plant traits at the leaf and canopy levels (e.g., transpiration, stomatal conductance, leaf temperature) using porometry, evapotranspiration chamber and thermography. These observations aim to better quantify water and energy fluxes and plant responses within the studied NbS.
The monitoring strategy is designed to support ecohydrological and process-based modelling frameworks, allowing upscaling from plants to overall NbS performance. Methodological challenges associated with integrating heterogeneous sensor networks are discussed. Linking plant functional traits with transpiration dynamics, drought response and cooling efficiency

will improve the predictive capability of NbS under current and future climatic conditions. Within the PENATE project, the resulting data will contribute to evapotranspiration assessment using plant-based (Radiation Absorption, Transpiration and Photosynthesis-RATP), climato-hydrological (Multi-Hydro, SOLENE) and multi-criteria (HIBOU) modelling approaches.

Keywords: Nature-based Solutions, soil–plant–atmosphere continuum, plant functional traits, thermo-hydric behaviour, urban hydrology

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Towards Climate-Neutral Cities: Preliminary Results From the GreenCities Framework for Integrating Nature-Based Solutions Into Urban Planning

Carla Sofia Santos Ferreira[1], Tomás de Figueiredo[2], Maria Santos[1], Zulimar Hernández[2] and Cong Cong[3]

[1]*Polytechnic University of Coimbra, Rua da Misericórdia, Lagar dos Cortiços, S. Martinho do Bispo, 3045-093, Coimbra, Portugal*
[2]*LA SusTec-Laboratório Associado para a Sustentabilidade e Tecnologia em Regiões de Montanha, Portugal*
[3]*Department of Urban Studies and Planning, Massachusetts Institute of Technology, USA*

Abstract

Cities account for more than 70% of global greenhouse gas emissions (GHGs) and are increasingly exposed to climate-related risks such as heatwaves, flooding, and declining environmental quality. Although many European municipalities have committed to achieving climate neutrality, local authorities still lack spatially explicit, evidence-based tools to identify where nature-based solutions (NBS) can deliver the greatest climate benefits. The GreenCities project addresses this challenge by developing an integrated framework that combines urban carbon emission mapping, assessment of carbon sequestration by urban green infrastructure, and GIS-based decision support for climate mitigation planning.
This contribution presents the first results of the GreenCities project, using Coimbra (Portugal) as a case study. A multidisciplinary methodology integrates geospatial datasets, high-resolution remote sensing, field measurements, laboratory analyses, and machine-learning techniques to quantify the climate mitigation potential of urban green infrastructure. Unlike most previous studies, the project considers both vegetation and urban soils as carbon reservoirs, providing a comprehensive assessment of ecosystem carbon storage and carbon flux dynamics.
CO_2 emission hotspots were identified by integrating high-resolution spatial emission inventories with GIS analyses to quantify emissions from the residential, commercial, industrial, and transportation sectors. Preliminary results reveal that the transportation sector is the dominant source of urban CO_2 emissions, highlighting priority areas for targeted mitigation interventions.
Carbon sequestration potential was assessed by integrating above- and belowground carbon pools. Vegetation carbon stocks were estimated from high-resolution remote sensing, biomass sampling, laboratory analyses, and species-specific allometric equations, while soil carbon stocks were quantified through field sampling and laboratory determination of soil organic carbon and bulk density. To complement carbon stock assessments, soil CO_2 emissions were

measured in situ using a portable infrared gas analyzer (LI-COR) coupled with a closed dynamic chamber across four representative urban green infrastructure types. The resulting soil respiration data provide insights into the temporal dynamics of carbon fluxes and contribute to evaluating the net ecosystem carbon balance of different urban green spaces.
The preliminary findings demonstrate the importance of integrating emission hotspot analysis with ecosystem carbon storage and soil carbon flux measurements to identify the most effective locations for NBS implementation. By combining advanced environmental monitoring with spatial decision support, GreenCities provides a replicable framework to guide climate-neutral urban planning, supporting evidence-based policies that maximize carbon sequestration while enhancing the multiple ecosystem services and community benefits delivered by urban green infrastructure.

Keywords: Nature-based solutions, Urban green infrastructure, Carbon sequestration, Climate neutrality

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Evaporation-Oriented Sponge City Roofs: a New Paradigm for Compensating Urban Sealing

Ralf Walker[1,*], Dieter Lohr[2], Winfried Krafft[2] and Heinz-Josef Schmitz[2]

[1]*ZinCo GmbH Lise-Meitner-Straße 2 72622 Nürtingen Germany, Germany*
[2]*Hochschule Weihenstephan-Triesdorf Institut für Gartenbau Am Staudengarten 14 85354 Freising Germany, Germany*

Abstract

Urban sealing fundamentally alters the natural water balance by reducing evapotranspiration, increasing surface runoff and intensifying the urban heat island effect. Although extensive green roofs are widely recognised as an important nature-based solution, their conventional design is primarily optimised for low maintenance rather than for maximum cooling and water-cycle restoration. Consequently, their contribution to urban climate regulation often remains below its potential.
This presentation introduces a new generation of evaporation-oriented Sponge City Roofs that combines permanent water storage, adaptive water management and high-transpiration vegetation to restore—or even exceed—the natural urban water balance. The concept follows the objectives of the German DWA Guideline M 102-4, which aims to approximate the hydrological conditions of undeveloped landscapes within urban environments.
Hydrological modelling based on the NatUrWB approach and DWA M 102-4 demonstrates that conventional extensive green roofs typically achieve evaporation fractions below those required to recreate natural site conditions. By integrating permanent retention layers, capillary water supply and vegetation with high evapotranspiration capacity, the proposed system substantially increases annual evapotranspiration while simultaneously reducing runoff and improving stormwater retention. Model calculations indicate that evaporation fractions can exceed the target values for natural water balances, thereby overcompensating for the hydrological impacts of urban sealing.
The presentation further discusses the importance of vegetation selection, controlled irrigation strategies and active water management for maximising cooling performance during prolonged dry periods. Experimental investigations and large-scale lysimeter facilities at the University of Applied Sciences Weihenstephan-Triesdorf provide the basis for validating long-term water balances and optimising future system configurations under realistic climatic conditions.
The presented approach represents a paradigm shift from conventional green roofs designed to rapidly drain water towards multifunctional roof systems that intentionally retain, redistribute and evaporate water. Such systems simultaneously contribute to urban cooling, stormwater management and climate resilience while supporting the transition towards sponge cities and circular urban water management.

Keywords: Sponge City Roof, Green Roof, Evapotranspiration, Urban Water Balance, Climate Adaptation

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From Tree Detection to Climate Action: a Digital Twin for Urban Greening and Heat Adaptation

Shaojuan Xu[1,*], Victoria Pissulla[2] and Sophia Chehregan[1]

[1]*Research Institute for Regional and Urban Development, Germany*
[2]*Ruhr University Bochum, Germany*

Abstract

Background
Increasingly frequent and intense heatwaves are prompting cities to expand green infrastructure as a key climate-adaptation measure. However, municipal tree cadasters typically document only publicly managed trees, excluding much of the privately owned urban tree stock. Although satellite imagery has been used to map vegetation, its spatial resolution is often insufficient to identify individual trees. Recent advances in high-resolution aerial imagery and deep learning have improved individual-tree detection, but their outputs have rarely been translated into operational planning tools. This study bridges the gap between research and practice by develop tree detection, green-volume estimation algorithms and transfer the output into an interactive urban digital twin.
Methodology
Individual trees were detected using deep-learning methods with high-resolution RGB aerial imagery. Three-dimensional LiDAR data were then used to estimate tree-canopy volume. The resulting public- and private-tree data were integrated into a WebGIS-based digital twin that dynamically visualizes tree-cast shadows for any selected location, date, and time. An interactive scenario tool was also developed to simulate the effects of proposed tree planting on local shade provision.
Results
The resulting digital twin provides a comprehensive representation of shade cast by both public and private trees. By calculating cumulative shade hours, the platform identifies urban areas with insufficient protection during hot periods and supports the prioritization of locations for greening interventions. The scenario tool allows planners to add virtual trees and immediately assess how alternative planting configurations affect shade coverage.
Policy and planning relevance
The platform has been applied by local-government staff and urban planners to support tree-planting decisions and climate-adaptation planning. By transforming remotely sensed tree data into actionable spatial evidence, the approach helps cities target green-infrastructure investment, evaluate planting scenarios, and improve outdoor thermal protection. The study demonstrates how digital twins can connect advances in urban-tree detection with practical, evidence-based strategies for greening cities and adapting to extreme heat.

Keywords: Green volume, tree detection, deep learning, urban digital twins, climate adaptation

UR3: Cross scale approach for NBS integrations in urban ecosystems

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Co-designing and Co-implementation for Climate Resilience: the AdaptWise Model and Pathways for Regional Scaling

Valentina Bucchi

Anci Toscana, Italy

Abstract

INTRODUCTION
As climate change exacerbates extreme weather events, urban and peri-urban systems face unprecedented challenges, particularly concerning water management and soil degradation. While Nature-Based Solutions (NBS) are widely recognized - among other kinds of adaptation solutions - for their capacity to enhance climate resilience, their long-term success heavily relies on participatory governance and social acceptance. This contribution responds to the UR3 session's call by presenting AdaptWise, an innovative Community-Based Adaptation (CBA) model designed to bridge the gap between technical adaptation to CC planning and local community empowerment. AdaptWise shifts the paradigm from top-down infrastructure delivery to a collaborative approach where citizens, public authorities and stakeholders actively co-design and maintain resilient landscapes.
THE ADAPTWISE METHODOLOGY
The AdaptWise framework is structured around a replicable, step-by-step methodology that places communities at the core of the adaptation process, specifically targeting soil and water vulnerabilities. It has been tested across 8 pilot sites.
1) *Contextual Vulnerability and Asset Mapping*: The process begins with participatory mapping, integrating scientific climate data (e.g., flood-prone zones, urban heat islands) with local ecological knowledge. This step identifies critical environmental vulnerabilities while simultaneously mapping existing social capital and risk tolerance.
2) *Stakeholder Engagement and Co-design*: Through structured workshops and capacity-building sessions, citizens and technical experts collaboratively design adaptation solutions, among which NBS. This phase ensures that the interventions are not only ecologically sound but also socially relevant and culturally integrated.
3) *Shared Implementation and Monitoring*: The final step involves the joint execution of the designed solutions, establishing clear roles for both the municipality and the community in the long-term stewardship of the implemented NBS.
2 CASE STUDIES
1) *Livorno*. In the coastal city of Livorno - an area highly susceptible to climate-induced water extremes and soil sealing - the process has successfully reached the implementation stage. The cornerstone of this operational phase is the establishment of a formal "Collaboration Pact" (Patto di Collaborazione) between the local community, civil society organizations, and the Municipality. This administrative tool is fundamental for participatory governance: it provides

a legal framework for citizens to actively manage public spaces and implement small-to-medium scale adaptation interventions. The Collaboration Pact transforms the signatories into active drivers of urban climate resilience, ensuring ownership and sustainability.
2) *Alghero*. A primary school's grounds and infrastructure were retrofitted utilizing targeted NBS, transforming a traditional educational facility into a climate-resilient community hub. This intervention not only addressed local soil and water management vulnerabilities but also established the school as a "living laboratory." By embedding NBS directly into the educational setting, the Alghero pilot fostered hands-on environmental awareness among younger generations and strengthened broader neighborhood engagement, proving that the methodology can be effectively adapted to institutional assets as well as public municipal spaces.

SCALING UP - A VISION FOR TUSCANY REGION

Having successfully spearheaded the regional integration of the FireWise Communities model for wildfire resilience, Anci Toscana is now advocating for a complementary step: adopting the AdaptWise methodology as a foundational framework for a new, parallel policy tool within the Tuscany Region. Anci Toscana's advocating for an open-call mechanism which would provide continuous financial support and technical accompaniment to local communities across the region upon their request. By institutionalizing the AdaptWise approach alongside its FireWise counterpart, the Tuscany Region can systematically empower local networks to implement localized NBS for soil and water management whenever community readiness aligns with local climate vulnerabilities.

CONCLUSION

Ultimately, AdaptWise illustrates that sustainable urban development requires robust social infrastructure alongside ecological engineering. By showcasing the Livorno and Alghero case studies and outlining a clear pathway for regional policy integration, this presentation provides a practical blueprint for cross-scale, community-led climate adaptation.

Keywords: Everyday adaptation, Relational durability, Transformative adaptation, Soft adaptation, Knowledge coproduction, Intersectional climate justice, Local knowledge, Community resilience, Community based adaptation

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Integrating Participatory Governance Into Urban Planning for Climate Resilience: Evidence From the Prin Urca! Project

Michele PEZZAGNO[1,*], Francesca Pirlone[2], Ilenia Spadaro[2] and Giovanna Grossi[1]

[1]*Università di Brescia, Italy*
[2]*Università di Genova, Italy*

Abstract

Climate change is increasing the frequency and intensity of urban flood events, requiring planning approaches that integrate risk prevention, adaptation, and stakeholder engagement. This research investigates the role of public authorities in embedding climate risk knowledge within statutory urban planning. It examines how participatory governance can support more effective and inclusive climate resilience strategies at the local level.
The study draws on the experience of the Italian PRIN 2020 project URCA! – Urban Resilience to Climate Change: Activating Participatory Mapping and Decision Support Tools for Enhancing Sustainable Urban Drainage, involving seven Italian universities. The project promoted urban resilience as a key component of sustainable development, contributing to Sustainable Development Goals 11 (Sustainable Cities and Communities) and 13 (Climate Action) through the implementation of Sustainable Urban Drainage Systems (SUDS) and participatory decision-making processes.
This abstract focuses on the comparative case studies of Genoa and Brescia, two cities representing different institutional and environmental contexts. Genoa is highly exposed to hydraulic risk and has an established tradition of participatory governance, although climate adaptation had not previously been addressed through participatory processes. Brescia has developed a long-term climate transition strategy integrating municipal planning instruments with participatory practices and collaborative forms of public space management.
Attention is devoted to the development of the URCA! Policy Brief, conceived as an evidence-based decision-support tool for policymakers and public administrators. Building on participatory mapping activities and stakeholder engagement, the Policy Brief translates research outcomes into operational recommendations for integrating participatory approaches into urban planning and climate adaptation policies.
The findings suggest that participatory governance enhances the capacity of local authorities to address climate-related risks by improving risk awareness, facilitating knowledge exchange among institutional and non-institutional actors, and supporting more informed and legitimate planning decisions. Beyond the specific case studies, the proposed Policy Brief demonstrates how research-based policy tools can bridge the gap between scientific knowledge and planning practice, providing a transferable framework for strengthening urban resilience and promoting more inclusive and climate-responsive governance.

Keywords: climate change, governance, public engagement

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A Fit-for-Purpose Framework for Ecosystem Service Assessment in Spatial Planning

Marialaura Giuliani and Anna Richiedei

University of Brescia, Italy

Abstract

The integration of ecosystem services (ES) into spatial planning has become increasingly widespread over the last decade, supporting territorial governance across multiple administrative and ecological scales (Malinga et al., 2015). ES assessments are now employed to inform strategic planning, environmental accounting, participatory governance, and land-use regulation. Despite this growing consensus, the selection of assessment methods often remains weakly justified. As highlighted by Albert et al. (2014), ES assessments should not be conceived as standardized procedures, but designed according to the decision-making context and feasibility conditions, including data availability, technical capacity, institutional settings, resources, and users' needs. These conditions determine the appropriate spatial scale, methods, valuation approaches, and outputs. Accordingly, The Economics of Ecosystems and Biodiversity (TEEB) initiative introduced the fit-for-purpose principle, emphasizing that methodological choices should reflect specific decision objectives.
A decision-support framework for aligning ES assessment approaches with planning objectives is proposed to address this gap. Building upon Albert et al., it develops a hierarchical assessment scheme and tests its application through pilot studies in Italy. The framework includes two levels: preliminary conditions defining objectives and feasibility, and an operational matrix linking methods, spatial scales, and outputs according to planning purposes.
The framework is subsequently interpreted through a simplified version of Lasswell's Policy Cycle (1956) to demonstrate how ES assessments should critically evolve across different stages of public decision-making. In particular, four planning objectives are distinguished.
The first, awareness raising, focuses on increasing the recognition of ES through participatory governance processes capable of incorporating plural and non-use values into territorial decision-making. This case did not produce quantitative assessment outputs: instead, it was developed as an arts-based participatory process of knowledge co-production involving civil society and local administrators, aimed at fostering shared understandings of ES and making plural, relational, and non-use values visible within territorial decision-making.
The second, accounting, supports strategic spatial planning through the construction of a territorial baseline. This objective is illustrated by the biophysical and monetary assessment of ES, following the operational guidelines developed by Italian Institute for Environmental Protection and Research (ISPRA). Although these guidelines prioritize operational applicability over methodological complexity, they provide a consistent basis for ecosystem accounting at

the sub-regional scale.
The third objective, priority setting, aims to identify territorial strategies based on a comprehensive understanding of ES provision. This stage is explored through a cross-scale assessment of cultural ecosystem services using the System of integrated Environmental and Economic Accounting- Ecosystem Accounting (SEEA EA) framework, which integrates the ecological scale of ES production with the administrative scale of spatial planning, supporting place-based strategies for natural capital enhancement.
Finally, instrumental design concerns situations in which ES assessments directly support planning instruments and land transformation decisions. Here, methodological robustness and valuation consistency become essential because assessment results influence regulatory choices and negotiations among multiple stakeholders. The proposed application combines the SEEA EA and the European Integrated system for Natural Capital Accounting (INCA) frameworks at the municipal scale to define a monetary metric for soil ES consistent with land market exchange values. This enables direct comparison between natural capital and real estate values, providing an operational basis for integrating ES into planning instruments such as ecological compensation schemes, Soil Value Capture, Transfer of Development Rights, and future Payments for Ecosystem Services (PES).
The proposed framework provides a transparent, critical, and operational framework for integrating ES into contemporary spatial planning and land governance. It emphasized the pivotal role of ES assessment in supporting the planning and implementation of Nature-Based Solutions (NBS), demonstrating how cross-scale governance approaches, interdisciplinary perspectives, participatory processes and are supported by evidence from concrete pilot applications.

Keywords: soil ecosystem services, ecosystem services assessment, spatial scale selection, spatial-planning decision making

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Integrating the Planetary Boundary for Freshwater Change Into Urban Water Management Through Nature-Based Solutions

Raghid Shehayeb

Leibniz Institute of Ecological Urban and Regional Development, Germany

Abstract

The transgression of global Planetary Boundaries (PBs), particularly concerning freshwater change (blue and green water) and climate stability, is heavily driven by increased urban consumption and land-use change. These Anthropocene changes generate severe societal and environmental risks, including risks for urban dwellers and ecosystems. Navigating the freshwater interface between the Earth system and societies requires a cross-scale approach that connects local socio-ecological needs and basic water security with the stabilization of critical global thresholds.
While Nature-based Solutions (NbS) and Urban Green Infrastructure (UGI) are increasingly implemented for local climate adaptation and water management, their ecosystem services (ES) face a duality: they are actively threatened by global environmental changes, yet they serve as vital local levers to counter PB transgression. Hence, this contribution aims to explore what are the requirements to operationalize the PB for freshwater change within urban water management, and how can NbS actively reduce the transgression of these boundaries? To examine these interlinkages, this study first provides the example of compound drought and heat risks on selected ecosystem services within an urban park in Plauen, Germany. To connect these local dynamics to the Earth system, the study further examines the global freshwater–society interface based on existing evidence from literature. This perspective synthesizes critical water-related interlinkages, planetary boundaries for freshwater change, and societal water needs, pointing toward innovations that reduce societal pressures on freshwater systems and build resilience to hydrometeorological extremes.
The findings demonstrate that while urban ES are highly sensitive to compound drought and heat hazards, safeguarding and adapting these green-blue infrastructures generates systemic, multi-scale benefits. By framing NbS as cross-scale operational tools rather than isolated local interventions, this study highlights how targeted urban water management can simultaneously build local climate resilience and contribute to remaining within Safe and Just Earth System Boundaries.

Keywords: Urban Water System, Nature-based Solutions, Ecosystem Services, Planetary Boundaries

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Assessing Soil Ecosystem Services From Urban Soils to Engineered Soils

Sara Mefaredj

University of Salerno, Italy

Abstract

Urbanisation is increasing the need for sustainable solutions that improve environmental quality while enhancing the resilience of urban areas. In this context, engineered soils can play an important role in Nature-Based Solutions (NBS) and Low Impact Development (LID) systems by supporting multiple soil ecosystem services. This research aims to assess the ecosystem services provided by healthy engineered soils in urban environments and to investigate how environmental conditions may influence their performance. The municipality of Parete, in Campania, Italy, is used as the case study. The current phase of the research combines GIS and remote sensing analyses, field sampling, laboratory soil characterisation and regional climatic assessment. Twenty soil samples were collected within the study area, while Landsat imagery was used to evaluate land-use change between 2006 and 2026. Preliminary analysis indicates rapid urban expansion (+70.8%) accompanied by vegetation loss (-18.5%). A regional temperature analysis was also carried out using meteorological data from selected stations across Campania. Parete shows a warming rate of approximately +0.60 °C per decade and an intermediate thermal regime compared with the other investigated stations. These preliminary results provide the environmental context for the next phase of the research, which will integrate soil, vegetation and atmospheric information to assess soil ecosystem services and support the future evaluation of engineered soils within NBS and LID applications. Particular attention will be given to functions related to stormwater management, infiltration, water regulation and urban climate resilience.

Keywords: Soil ecosystem services, Nature-Based Solutions, Low Impact Development, Urban soils, Climate resilience

UR3: Scaling Urban Nature-Based Solutions: Governance, Trade-Offs and Multi-Stakeholder Action

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Phosphorus Accumulation and Leaching in Compost-amended Urban Soils: Implications for Nutrient Management in Nature-based Solutions

Gaston Small

University of St. Thomas (Minnesota), United States

Abstract

Urban agriculture is increasingly promoted as a nature-based solution to enhance food security, recycle nutrients, and improve urban soil function. Compost amendments, in particular, are widely used to build soil fertility and close urban nutrient cycles. However, when compost is applied to meet crop nitrogen (N) demand, it can result in substantial phosphorus (P) over-application, with implications for soil P accumulation and downstream water quality.

We present results from a 10-year field experiment in an urban vegetable production system in which manure-based and municipal composts were applied either at rates designed to meet crop N demand (high-input) or crop P demand (low-input), alongside unfertilized and synthetic fertilizer controls. High-input compost treatments led to progressive accumulation of plant-available soil P and elevated phosphate concentrations in leachate, indicating increased risk of P export from urban soils. Over the first seven years, only ~30% of applied P was recovered in harvested biomass under high-input compost management, compared to >88% under P-based compost application. Leachate losses accounted for ~10% of total P inputs in manure-based compost treatments and ~4% in municipal compost treatments. Despite exceeding estimated crop N demand, high-input compost plots also showed evidence of N limitation in the absence of supplemental fertilizer, highlighting mismatches in nutrient stoichiometry.

These findings demonstrate a critical tradeoff in compost-based urban agriculture: while supporting soil health and nutrient recycling, current management practices can compromise water quality through P accumulation and export. We argue that aligning compost application with crop P demand—rather than N demand—is essential for maintaining soil function and minimizing environmental impacts. This work highlights the need for integrated nutrient management strategies within nature-based solutions frameworks to ensure that urban soil systems simultaneously support food production, nutrient retention, and water quality protection.

Keywords: urban agriculture, nutrient recycling, ecosystem services

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Soil (and Water) Steering in Spatial Planning: Spades

Fransje Hooimeijer

TU Delft, Netherlands

Abstract

Soil health is a cornerstone of sustainable ecosystems, yet it is under unprecedented pressure from climate change, urbanisation and land degradation. The EU-funded Horizon Europe SPADES project, SPATIAL PLANNING AND DESIGN WITH SOIL, address these challenges by integrating soil health into spatial planning and design. The mission is to support Europe's transition to healthy soils by empowering policy makers, practitioners and communities. By promoting soil literacy and creating adaptable tools, SPADES is putting soil health at the heart of planning for the benefit of current and future generations.

Keywords: spatial design, soil literacy

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UR4: Phytomanagement as Nature-Based Solution for sustainable land management

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Accounting for Wider Values to Develop Business Cases for Phytomanagement

Paul Drenning[1,*], Jenny Norrman[1], Yevheniya Volchko[1], Lars Rosén[1], Marie Veys[2] and Dain Jung[2]

[1]*Chalmers University of Technology, Sweden*
[2]*LGI Sustainable Innovation, France*

Abstract

Phytomanagement offers a nature-based solution (NbS) to manage risks at contaminated land while maintaining productive land use for biomass production and generating co-benefits, yet deployment at scale is often constrained by weak business cases that limit long-term financial viability. This presentation focuses on how accounting for wider values can strengthen the value proposition of phytomanagement projects and support financially viable, profitable phytomanagement strategies, with particular attention to biomass production and valorisation as a revenue stream. Building on approaches developed in the EU Horizon Soil project, ISLANDR, a practical framework for developing business cases at brownfield sites will be presented with key considerations for designing a phytomanagement strategy. The framework includes the following main steps: (i) identifying relevant wider values beyond risk reduction and compliance, (ii) quantifying and economically valuing these wider benefits, (iii) demonstrating financial and social viability over the project life, and (iv) selecting financial mechanisms that capture external value into investable revenues or cost savings.

The framework starts with a wider values exploration to identify and prioritize relevant wider values for stakeholders and decision-makers (e.g., reduced contaminant exposure, improved soil functions, urban greening and amenity, carbon storage, biodiversity support, microclimate regulation, and place-based regeneration), many of which are delivered by NbS such as phytomanagement. These are paired with context-appropriate economic valuation methods, including market pricing for biomass outputs, avoided cost and replacement cost methods, value transfer, and stated or revealed preference approaches, so that non-market impacts can be expressed in monetary terms alongside conventional cost items. The resulting monetised costs and benefits can be analysed to assess financial and economic viability as well as distinguishing who pays, who benefits, and when benefits materialise, enabling transparent discussion of distributional effects and risk. To bridge the “financial case” and the “economic case”, internalisation to capture wider values using financial mechanisms such tax incentives, grants, green finance (e.g., payments for ecosystem services, carbon and biodiversity credits), public–private partnerships, etc. are discussed. Central to the phytomanagement business model is biomass handling and valorisation pathways to ensure a profitable and sustainable land management strategy. Results from a recent study exploring strategies to combine phytomanagement using bioenergy crops with producing biofuels for the maritime industry will

be highlighted.

This presentation is expected to contribute to the rapidly developing field of phytomanagement as a nature-based solution by supporting the development of business cases for long-term financial and social viability.

Keywords: Economic valuation, Cost-benefit analysis, Business case, Ecosystem services

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Achieving Natural Reclamation From Spontaneous Forest in Urban Context

Gianluca Rapaccini[1,*], Laura Passatore[2], Zeno Porro[3], Giovanni Trentanovi[2], Brenda Maria Zoderer[4], Gabriele Galasso[5], Roberto Comolli[6] and Paola Pirelli[7]

[1]*Terrapreta Srl SB, Italy*
[2]*Research Institute on Terrestrial Ecosystems (IRET), National Research Council (CNR), Italy*
[3]*Institute of Biology, Freie Universität Berlin, Germany*
[4]*Department of Landscape, Water and Infrastructure, Institute of Landscape Development, Recreation and Conservation Planning, BOKU University, 1180 Vienna, Austria*
[5]*Sezione di Botanica, Museo di Storia Naturale di Milano, Italy*
[6]*Dipartimento di Scienze dell'Ambiente e della Terra (DISAT), Università degli Studi di Milano Bicocca, Italy*
[7]*Centro di Forestazione Urbana—Italia Nostra Aps, Sez. Nord Milano, Italy*

Abstract

In the face of mounting challenges related to limited availability of urban land and ecological degradation, emerging novel ecosystems offer unique opportunities for ecological regeneration, social redefinition of space, and alternative urban visions.
The study presents the multi-layer analysis of the Goccia Forest in Milan (Italy), a wild urban woodland that has developed over sealed and polluted post-industrial land, aiming to investigate the potential of this novel ecosystem to sustain Nature-based Solutions (NbSs). Using an integrated approach (surveys on fauna, vascular flora, lichens, analysis of forest evolution, mapping of sealed surfaces, and soil characterization) the research looks at the novel ecosystem as a whole, highlighting its ecological dynamics and Ecosystem Services (ES). La Goccia Forest serves as a prime example of how the implementation of NbSs is intricately intertwined with the spontaneous regeneration of urban brownfields. The study also want to offer the opportunity to rethink urban policies, ensuring their alignment with the demands of the population and the latest scientific knowledge.
In fact, cities are facing interconnected climatic, social, and economic challenges that require integrated adaptation responses. Nature-based Solutions (NbS) have the potential to act as multi-problem solvers, delivering environmental, social, and economic benefits simultaneously. However, scaling NbS, specifically in urban remediation sites, could be very complex, requiring long-term vision and interdisciplinary approach.
This session will highlight opportunities, challenges, risks and trade-offs for delivering NbS at scale in urban remediation, with a focus on the practical application of political issues, landscape visions, and scientific challenges.
The session will present the case study of Osservatorio La Goccia, an interdisciplinary, multi-stakeholder initiative involving 11 partners—including SMEs, universities, and

associations—designed to address complex challenges such as the application of NbS for natural reclamation in urban areas. The case study concerns an 18-hectare site with multiple forms of contamination, formerly the Gas Works, on which a novel ecosystem has grown.
The session will present the interdisciplinary approach used to establish the multi-layer baseline analysis and conduct integrative studies on soil, biomass and microbiome, aimed at assessing the phytoremediation potential of the natural forest. Then the results achieved at the policy level, as well as the procedural challenges encountered in implementing innovative Nature-based Solutions, such as rizodegradation, phytostabilization and natural attenuation, will be highlighted.

Keywords: Phytoremediation, Interdisciplinary, Urban, Multi-contamination, Novel ecosystems

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From Total Contamination to Functional Risk: Phytoavailability Indicators for Contaminated Soils

Senda ZARROUK

Agroparistech/PEM education, France

Abstract

Managing trace metal contaminated soils requires a shift from static contamination assessment towards functional risk evaluation. Conventional regulatory approaches often rely on total metal concentrations, which remain useful for screening and compliance, but provide limited information on what plants actually experience at the soil root interface, where metal mobility, uptake and ecological risk are dynamically expressed. This presentation proposes a phytoavailability based perspective for improving the management of trace metal contaminated agricultural soils within a Nature Based Solutions framework. Drawing on research on cadmium and lead uptake by plants growing on soils amended with sewage sludge and urban compost (Zarrouk et al., 2014), it argues that contamination should not be assessed only as a stock, but also through the fluxes that determine exposure, including desorption, diffusion through the soil solution, complexation and decomplexation processes, rhizosphere interactions and root uptake. These mechanisms are influenced by soil properties such as pH, organic matter, texture, mineralogy and amendment history. Phytomanagement offers a relevant pathway to address contaminated land without reducing soil to a passive or degraded support. By combining plant based strategies, soil amendments and long term monitoring, it can contribute to risk reduction while preserving or restoring key soil functions. Yet its credibility depends on indicators capable of linking contamination, bioavailability, plant uptake and decision making. Dynamic indicators, including soil plant transfer metrics and diffusive gradients in thin films, can support more operational risk assessment, as recent studies confirm the relevance of DGT for evaluating metal bioavailability to crops (Senila et al., 2024) and show that total soil concentrations alone may be inadequate for assessing cadmium bioavailability in soil crop systems (Cheng et al., 2025). The presentation will examine how such indicators may inform European soil policy, sustainable land management and Nature Based Solutions for contaminated agricultural landscapes. The central argument is that sustainable phytomanagement cannot rely only on measuring how much contamination is present. It must evaluate how contamination behaves, how it becomes available and how it affects living systems. Moving from total concentration to functional risk is therefore essential for designing credible, science based and policy relevant solutions for contaminated soils.

Keywords: Phytoavailability, cadmium, contaminated soils, phytomanagement, Nature-Based Solutions, functional risk

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The Use of Phytoremediation for Removal of Heavy Metals in Urban Soils

Macartney Wormington[1,*], Elise de Laulanié[1], Anna Espinoza[1], Laetitia Sehad[2] and Sarah Berns[2]

[1]*Luxembourg Institute of Science and Technolgy, Luxembourg*
[2]*GeoConseil, Luxembourg*

Abstract

Urbanization is rising globally to fit the demands of the growing population. With an increase in urban centers, urban soil health has become increasingly important. Healthy soils are those that have good biological, chemical, and physical conditions and can therefore provide ecosystem services. These soil ecosystem services include storing carbon, purifying water, cycling nutrients, and contributing to flood mitigation. Healthy urban soils also offer provisioning services, such as the production of food in urban gardens, and cultural services, including the use of green-spaces for physical and mental well-being of residents.
Currently, infrastructure and the acquisition of raw materials are prevalent uses of soils in the European Union (EU). These usages have led to the degradation and continual deterioration of soil health. In Luxembourg, the historical steal industry and urbanization have left polluted soils in its wake. The prevailing approach employed in Luxembourg for addressing polluted soils is the excavation and subsequent disposal in authorized landfills. This method is destructive to the soil structure, limiting its ability to perform ecosystem services. The EU Green Deal, Circular Economy Action Plan, Biodiversity Strategy, and Soil Monitoring Law highlight the importance of addressing soil degradation in a sustainable way. The URSOILL project aims at contributing to urban soil remediation by testing innovative solutions. Specifically, the Urban Living Lab Luxembourg will investigate nature-based solution and new technologies on soil engineering, including phytoremediation, to improve urban soil health.
Phytoremediation harnesses plants and their associated microbes to clean the environment they are apart of. In the case of pollutants like heavy metals, phytoremediation is used to remove them from the soil and store it within the plant's shoot through a process called phytoextraction. As phytoremediation does not require the excavation, washing, or burning of soil like more traditional methods, it keeps the soil intact and offers a more sustainable method for remediating the environment. Additionally, it is less costly than traditional methods that require more labor or tools. For an urban garden and URSOILL experimental site, bio-remediation tools like this hold promise in reaching its goal of improved soil health. Past analyses have shown heavy metal pollution in the soil, namely arsenic and zinc, as well as chromium in certain crops. Based upon the site's baseline, it is recommended to use phytoremediation methods to improve soil health and ensure safe crops for the community. These implemented methods will be continually monitored to contribute to remediation protocols.

Keywords: Soil health, Pollution, Phytoremediation, Urban soils

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When Is Poplar-based Phytomanagement of TPH-contaminated Soils Feasible? a Dynamic Integration of Degradation Kinetics, Tree Growth, Ecosystem Services and Life Cycle Assessment

Lidia Favaretto[1,*], Anna Espinoza[2] and Claudio Petucco[2]

[1]*Department of Biotechnology and Biosciences, University of Milano-Bicocca, Piazza Della Scienza 2, I-20126 Milan, Italy*
[2]*Luxembourg Institute of Science and Technology (LIST), 41, rue du Brill, L-4422 Belvaux, Luxembourg*

Abstract

The application of phytoremediation is often constrained by the difficulty of predicting when remediation targets will be reached and what benefits the system delivers in the meantime. Without time-explicit estimates of both attenuation and co-benefits, nature-based remediation options are frequently discarded in favour of conventional, more disruptive techniques, despite the greater environmental, economic, and social costs (Drenning et al., 2022).
This work presents a dynamic modelling framework for poplar-based phytomanagement of soils contaminated by total petroleum hydrocarbons (TPH). Rhizodegradation kinetics reported in the literature are coupled to a system dynamics model simulating poplar growth under contaminated conditions. Biomass development and contaminant attenuation are therefore represented as mutually dependent processes: root system development drives rhizosphere degradation, while contaminant-induced stress feeds back on plant growth.
A further feature of the framework is the dynamic quantification of the provided ecosystem services. For instance, CO2 sequestration is computed from simulated above- and below-ground biomass accumulation and from litter-derived soil organic carbon inputs; air contaminant removal and stabilisation are tracked as cumulative mass over time; further regulating services, such as runoff avoidance, are linked to canopy and root development. This highlights the trade-offs between remediation time and the provision of benefits over longer time horizons.
Moreover, the model outputs are integrated with a Life Cycle Assessment, weighing the environmental burdens of the phytomanagement system against the quantified benefits. This covers cuttings production in nurseries, establishment of the phytoremediation plantation, and its management until the legal pollution threshold is reached. Beyond this stage, different scenarios are modelled to describe possible subsequent uses of the area planted with poplars. The net economic impact of phytomanagement, combining environmental costs and benefits, can be eventually calculated across all the considered life cycle phases.
The framework thus provides a decision-support tool for designing and screening phytomanagement projects, particularly relevant for urban and peri-urban brownfields. While feasibility remains the primary requirement for remediation, weighing life cycle impacts

against co-benefits and risk reduction is what could drive a wider and more responsible application of nature-based remediation options.

Keywords: phytomanagement, system dynamics, ecosystem services, Populus spp, life cycle assessment

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From Pollution to Production: Assessing Hemp as a Brownfield Opportunity

Stanley Lutts[1] and Nolan Regnier[2,*]

[1]*Université catholique de Louvain (UCLouvain), Belgium*
[2]*UCLouvain, Belgium*

Abstract

Brownfield soils often present substantial constraints for crop production, including coarse texture, low organic matter, limited water retention, reduced fertility and, in some cases, heavy metal contamination (Oliver et al., 2005). Within a phytomanagement framework, hemp cultivation may offer a promising option to limit pollutant impacts while providing an non-food economically valuable crop. Hemp contributes to carbon sequestration, and its rapid growth suppresses weeds. It requires relatively few inputs, making it well suited to low impact agricultural systems (Parvez et al., 2021). Its deep taproot, reaching up to 2 metres, enables access to large soil volumes and supports resilience under contrasting edaphic conditions (Amaducci et al., 2008). In addition, the recent rise in natural fibre prices strengthens the prospects of this emerging sector (Fagnant, 2025).
This study assessed the feasibility of hemp (Cannabis sativa) cultivation using two cultivars (Santhica 27 (fibre oriented) and Futura 75 (biomass oriented) on three contrasting sites in Wallonia (Belgium) : an agricultural soil, an uncontaminated brownfield and a contaminated brownfield. Across sites, germination, plant survival and vegetative development were not significantly affected by industrial soil characteristics or heavy metal presence. Hemp grown at Sclessin accumulated only low metal levels, confirming its suitability as a safe non food crop on contaminated land. Yield differences were driven mainly by agronomic factors such as water availability, organic matter content, soil texture and C/N ratio. Fibre quality remained stable across soils, reflecting strong genetic control over cellulose, hemicellulose and lignin contents, and shive composition showed no detectable influence of heavy metals.
Overall, the contaminated Sclessin site appears suitable for hemp cultivation, whereas the extremely low organic matter content and high C/N ratio at Ottignies limit its potential without intervention. Achieving viable yields will require targeted improvements such as organic matter amendments, pH correction and enhanced water management. These findings also highlight that brownfield suitability depends not only on soil properties but also on pollutant level and mobility, which govern plant uptake and long term site behaviour.

Keywords: hemp, heavy metals, brownfields, production

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UR5: Open session on NBS in urban environments

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Cementitious Permeable Pavement as a Reflective Adsorptive-filtration Urban Interface for Passive Source Control of Particulates, Chemicals, Rainfall-runoff and Temperature

John Sansalone

University of Florida, United States

Abstract

With historical roots across the Roman empire, deployment of permeable pavement as an engineered system can become a modern disruptive technology that are beneficial to the urban climate, water cycle and human health. In the USA, states such as Florida have a growing permeable pavement industry. In the last decade there have been significant technological advances for the manufacture and analysis of permeable pavements. The tools are now available to demonstrate that permeable pavement can provide a durable structural surface for vehicles and provide hydrologic, chemistry and particulate matter (PM) management while reducing thermal pollution, in comparison to conventional impervious asphaltic pavement while reducing the reliance on fossil fuels. Applications of cementitious permeable pavement (CPP) have demonstrated the potential to provide a sustainable and passive green infrastructure that provides unit operations (e.g. filtration) and processes (e.g. surface complexation) mechanisms for management of wet weather urban drainage. Specific aspects of this control have been the subject of significant research from field application and mechanistic elucidation from controlled testing, including filtration, hydrologic restoration and the potential for clogging. This study investigated behavior of CPP subject to PM loadings for a hetero-disperse particle size gradation, a sandy-silt gradation. Tested and monitored at an interstate highway (I-75 Cincinnati, OH USA) catchment, subject to runoff loadings, CPP specimens were examined by x-ray tomography and had similar pore size distributions and effective porosity. Total PM mass removal efficiencies ranged from nearly total removal for medium and coarse sands to greater than 60% for fine silt-size particles. With an engineered surface matrix, total metal and phosphorus reductions exceeded 80%. The commensurate turbidity reductions were significant, and effluent turbidity was reduced by 50 to 90% compared to influent values. Saturated hydraulic conductivity of the clean-bed CPP was in the range of 0.1 to 0.01 cm/s, followed a first-order exponential decline with PM loadings, and restoration of this hydraulic conductivity required pavement cleaning approximately once every six-month period. Cleaning by pavement vacuuming restored up to 95% of clean-bed hydraulic conductivity. In-situ hydrologic restoration was significant, generating peak flow reductions and storage within the pore space that represented approximately 25% of CPP volume. The effluent response from the influent hydrograph was attenuated (peak, volume, duration) as compared to the response of conventional impervious pavement. Regulatory load

credits for metals and nutrients have been provided for over a decade for the implementation and maintenance of such practices that equate to millions of dollars (USD) saved annual by even a small municipality for documentation of such implementation and maintenance.

Keywords: Urban drainage, wet weather flow, x-ray tomography, hydraulic conductivity, green infrastructure, urban water cycle, urban heat island

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Optimizing Urban Water Clarification Systems as Green Infrastructure for Water Reuse

John Sansalone

University of Florida, United States

Abstract

As a common unit operation within water management systems, volumetric stormwater clarifiers (or as tanks/tunnels below-grade) are widely implemented for hydrologic control, constituent (particulate matter, PM and chemical) load reduction from urban drainage as well as a subsequent reuse water source. Despite ubiquitous applications, optimizing cost-benefit based on planning/design or needed retrofits of such units is often not considered in engineering practice. As a result, basin initial planning/design yield high costs (i.e., total design cost includes land acquisition costs, operation and maintenance costs, and construction costs) from hundreds of thousands to tens of million US dollars (USD) per unit operation system. Many of these clarification units are impaired because of the use of inadequate design/analysis tools such as residence time (RT) indices that only provide presumptive guidance for treatment, lack of regular maintenance or through the non-stationarity of loadings from further imperviousness in urban land uses. Retrofits, if even feasible, yield even higher costs, noting that RT-based solutions require increased unit volume and surface area. The high cost of clarifiers imposes substantial financial burden for stakeholders. Optimized design/retrofit can reduce the cost at a given level of benefit for this common green infrastructure system for reuse water. Recent studies demonstrate using computational fluid dynamics (CFD) simulation to optimize and guide basin design can significantly reduce clarifier costs with even greater reductions (two orders of magnitude) when CFD is coupled with machine learning (ML) for a given level of treatment. Compared to existing tools (RT, CSTR software tools), a CFD-ML model, DeepXtorm can provide a much more robust and significantly improved cost-effective design. From benchmarking with measured data from across Florida clarifiers, DeepXtorm consistently yield much lower cost than existing tools with respect to a range of presumptive design criteria based on PM as total suspended solids (TSS), total phosphorus (TP) and metals; common water chemistry parameters that are regulated. The improved basin cost-benefit in DeepXtorm is fundamentally provided by the constrained non-linear optimization and CFD-ML engine, which allows DeepXtorm to efficiently explore the design parameter space that no current model is able to accomplish. Beyond the research applications, future work is the creation of a web-based user-friendly application interface for engineering practice.

Keywords: Computational fluid dynamics, machine learning, unit operations, hydrodynamics, residence time, clarification, cost-benefit, urban drainage, water reuse

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UR7: Nature-Based Solutions for Climate-Resilient Urban Spatial Planning and Sustainable City Development (Panel)

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Nbs Implementation in Lombardy Region: the Experience of Contratti Di Fiume

Franco Raimondi

ERSAF (Regional Agency for Agriculture and Forestry Services), Italy

Abstract

The intensification of extreme atmospheric events, especially stormwater events, due to climate change, combined with soil sealing and green areas reduction, are leading to an increasingly critical and widespread hydraulic risk especially in densely urbanized areas. Lombardy Region is the most densely populated area in Italy and one of the most in Europe. In particular, the area north of Milan has a waterproofing rate exceeding 60 %. The occupation of floodplains, the lack of sewer systems updates and the disappearence of green areas have made the area particularly prone to flooding that occur with high frequency. Furthermore, extreme stormwater events are expected to increase in the coming years according to climate forecast, therefore a change in urban spatial planning and the adoption of strategies to climate change adaptation are now urgently needed. Nature Based-Solutions (NBS) constitute a valid strategy for the reduction of hydraulic risk impacts while simultaneously offering further benefits such as heat islands reduction, biodiversity support, water quality and social and wellness improvement. NBS play a key role in hydrological cycle restoration altered by urbanization, improving the natural processes of storage, evapotranspiration and infiltration. For the successful implementation of NBS, rethinking urban spatial planning, improving public acceptability and enhancing stakeholders involvement are required. ERSAF, the Regional Agency for Agriculture and Forestry Services, supports the Lombardy Region in implementing sustainable water management policies. Specifically, through the promotion of Contratti di Fiume, a voluntary agreement between all stakeholders living and working within a river watershed, as a new process for fluvial territory planning, it aims to build resilient communities based on shared goals and by developing multidisciplinary projects, among which NBS. Contratti di Fiume seek to change the mentality in planning and living urban space according to European Directives, national legislation and sectoral plans but with a deep knowledge of territory needs and potentialities. In particular, in collaboration with the Lombardy Region, ERSAF developed, in 2021-2022, a Call4Ideas for projects concerning public areas re-greening through the introduction of NBS for climate change mitigation and adaptation. It represents the first initiative in Italy to fund projects on this topic, which include the identification of criteria and indicators related not only to hydraulic issues but also to water quality, biodiversity support, fruition and CO_2 reduction and absorption. 14 municipal projects have been funded, including solutions such as rain garden, bio-retention areas, infiltration trenches, green roofs, tree boxes, dry and wet ponds and permeable pavements. Currently, the results of the already completed projects are being monitored. Once they are all

completed, they will allow the creation of approximately 13,000 m^2 of new green areas, most of which occupied by NBS, the de-sealing of approximately 47,000 m^2, and a volume of rainwater diverted from the sewer system of more than 4,000 m^3. Moreover, once all the projects have been completed, the goal will be to assess the data more strategically, investigating positive impacts not at site-specific level but at the river watershed scale, defining a standard and replicable method for monitoring and quantifying these benefits and estimating target for each river watershed involved in the River Contract. As a first result of the success of the Call4Ideas and thanks to the dissemination carried out by ERSAF through the Contratti di Fiume, many other municipalities in Seveso and Lambro River watershed, the two most affected by hydraulic risk in Lombardy, have begun to propose further de-sealing interventions through NBS which, once financed and completed, would allow for the de-sealing of an additional 170,000 m^2 of land.

Keywords: Nature-Based Solutions, Climate Change, Contratti di Fiume, De-sealing

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Governing Climate Adaptation: Linking Research, Local Government, and Society in Trier-Saarburg.

Feras Youssef

District Administration Trier-Saarburg, Germany

Abstract

Climate change Adaptation has become an urgent priority as communities seek to find options and ways in responding to the far-reaching impacts of a changing climate. Effective adaptation is not solely a technical or environmental challenge; it is a collaborative process that requires sustained interaction, integration, and cooperation among a broad range of stakeholders, including scientific and research institutions, government authorities, policymakers, and civil society.
The district of Trier-Saarburg has embarked on a comprehensive adaptation process through the development of a sustainable climate adaptation concept. Currently under development, the concept aims to provide a strategic framework for understanding and responding to the district's climate-related challenges. The final version is expected to identify areas particularly vulnerable to climate change—the so-called "hotspots"—and to define appropriate measures for reducing associated risks, strengthening resilience, and supporting sustainable adaptation at the local level.

This article examines the key pillars underpinning effective climate change adaptation and considers the distinct yet interconnected roles they play in adaptation process. Drawing on the experience of Trier-Saarburg, it further presents practical examples, lessons learned, and tips into the institutional and collaborative dimensions of adaptation. Particular attention is given to the coordination and management mechanisms established among relevant stakeholders.

Keywords: Climate-change adaptation, Research, Society

MET1: Integrated Methodologies for Measuring Implementation and Impacts of Equitable Nature-Based Solutions and Green-Blue Infrastructures

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Integrated Co-creation Methodology for Nature-based Solutions: a GreenME Approach to the Impact of Green Care on Mental Health

Lizzy Moonga

ILS - Institute for Urban and Regional Development, Germany

Abstract

Nature-based Solutions (NbS) and green-blue infrastructure (GBI) are increasingly recognised as essential strategies for addressing interconnected socio-ecological challenges, including climate change, biodiversity loss, and declining mental health and well-being. However, significant gaps remain in translating existing frameworks into integrated, operational methodologies that support implementation, monitoring, and evaluation across diverse contexts.
This paper presents the GreenME project's integrated co-creation methodology as a practical approach to operationalising NbS through participatory, participatory processes. Implemented across seven countries, the methodology combines stakeholder workshops, interdisciplinary collaboration, and user-centred perspectives to co-design context-specific pathways for Green Care "" interventions. Engaging policymakers, practitioners, civil society, and researchers, the process identifies key preconditions, actionable measures funding and governance mechanisms for upscaling Green Care in urban and peri-urban settings.
Aligned with One Health and Planetary Health frameworks, the GreenME approach integrates social, ecological, and governance dimensions, while explicitly addressing equity and inclusion in access to green and blue spaces. It also contributes to the development of evaluation frameworks and methodological tools for assessing mental health outcomes, ecosystem services, and long-term sustainability.
Preliminary findings from the stakeholder's co-creation workshops including overarching actionable measures for implementing and upscaling Green Care. Some of the highly suggested areas by stakeholders across the project countries include:

- Guidelines and Regulation
- Evidence and Research
- Financing and Financial models
- Qualification and Standardisation
- Networks and Coordination
- Pilot & Experimentator

These findings demonstrate how co-creation methodologies can generate robust, context-sensitive evidence, strengthen stakeholder ownership, and support the integration of Green Care into policy and planning processes. By bridging the gap between theoretical principles and practical implementation, the GreenME approach offers a transferable model for

advancing equitable, evidence-based NbS and GBI development across diverse socio-ecological contexts.

Keywords: Nature-based Solutions, Green-Blue Infrastructure, Green Care, Co-creation, Methodologies, Participatory Approaches

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GeoAI and Self-Supervised Earth Observation Framework for Measuring Nature-Based Solutions and Climate-Resilient Landscape Transitions Across African Socio-Ecological Systems

Shimeles Tadesse Zelelew

Space Science and Geospatial Institute (SSGI), Ethiopia

Abstract

Nature-Based Solutions (NbS) are increasingly recognized as transformative approaches for addressing climate change, biodiversity loss, land degradation, and water insecurity while enabling climate-resilient and circular socio-ecological transitions within planetary boundaries. Despite strong policy relevance, a persistent limitation remains: the absence of scalable, transferable, and uncertainty-aware measurement systems capable of quantifying NbS impacts across heterogeneous landscapes.

This study introduces a novel GeoAI framework that advances NbS monitoring by integrating multi-source Earth Observation (EO) data with Self-Supervised Learning (SSL) to enable scalable, label-efficient, and globally transferable ecological representation learning. The framework uniquely fuses Sentinel-1 synthetic aperture radar (SAR), Sentinel-2 multispectral imagery, Landsat 8/9 time series, MODIS vegetation dynamics, and NASA GEDI LiDAR canopy structure data within a cloud-native Google Earth Engine environment.

The key novelty lies in shifting from traditional supervised EO mapping toward self-supervised geospatial foundation representations that learn directly from large-scale unlabeled Earth observation archives. This enables robust cross-biome generalization and reduces dependency on ground-truth data, which is often scarce or inconsistent in African socio-ecological systems.

The framework is designed and evaluated at continental scale across African socio-ecological systems, covering key biomes including the Sahel, East African highlands, Congo Basin, and semi-arid dryland regions.

From learned representations, a suite of NbS-relevant indicators is derived, including ecosystem condition, vegetation recovery trajectories, land degradation risk, restoration suitability, and canopy structure dynamics. These indicators provide a unified and physically interpretable description of ecosystem functioning and landscape transformation processes.

A structured validation strategy is introduced, combining cross-biome transferability assessment, benchmarking against global EO products (ESA WorldCover, MODIS NDVI, Hansen Global Forest Change, and GEDI canopy height), and temporal stability analysis using multi-year satellite observations. Uncertainty is explicitly quantified using ensemble-based variance propagation to support robust decision-making under data-limited conditions.

By integrating GeoAI, SSL, and multi-sensor EO within a unified operational pipeline, this work advances the measurement science of NbS and supports international policy frameworks

including the SDGs, UN climate conventions, and the EU Green Deal. It provides a scalable pathway toward operational monitoring of climate-resilient landscape transitions in data-scarce regions.

Keywords: Nature-Based Solutions, GeoAI, Earth Observation, Self-Supervised Learning, Climate Resilience

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Integrating Nature-based Solutions and Ecosystem Service Assessment: Evaluating the Contribution of Green Infrastructure in Urban Landscapes

Lina Einenkel, Harald Zepp and Lars Grünhagen

Ruhr-Universität Bochum, Germany

Abstract

Nature-based Solutions (NbS), realized by improving Green Infrastructure (GI), are increasingly recognized as effective approaches for addressing climate change, biodiversity loss, and the growing demand for resilient landscapes and urban areas. At the same time, the assessment of ecosystem services (ES) provides valuable information for quantifying the benefits of GI and ecosystems. NbS are one possible solution to current societal challenges. The potential of NbS can substantiated by quantifying ES. Furthermore, NbS with ES assessment can make the multifunctionality of Green Infrastructure more transparent and strengthen decision-making in spatial planning.
This contribution presents a case study from the Ruhr Metropolis, Germany, to demonstrate how ecosystem service assessment can be used to evaluate the effects of Green Infrastructure measures implemented as Nature-based Solution. The analysis focus on ecosystem services, that are particularly relevant in the context of climate adaption and sustainable land management.
The assessment is carried out using the EnhancES Toolbox developed within the IMECOGIP project (BMFTR, FKZ 01LE1805A-B2). The QGIS-based toolbox provides a framework for spatially explicit quantification of ecosystem services offered by different Green Infrastructure elements, based on an understanding of ecosystem functions. By specifically identifying areas that could be transformed and calculating anticipated ecosystem services values in EnhancES optimized Nature-based Solutions can be suggested. By comparing the ES of the area in its existing land cover with scenarios that incorporate additional Green Infrastructure elements, the approach enables an evaluation of the potential contribution of NbS to ES provision.
The presented approach illustrates how combining Nature-based Solutions with quantifying and modelling ecosystem services in an urban area can strengthen planning processes by providing transparent and spatially explicit evidence for the benefits of Green Infrastructure. By combining NbS and ES, plans can be supported with concrete values in order to address societal challenges in urban areas.

Keywords: Nature-based Solutions, ecosystem services, Green Infrastructure, spatial planning, climate adaption, biodiversity loss

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Invisible Barriers and Perceived Motivations for Green Care in Green and Blue Spaces

Shaojuan Xu, Kathrin Specht, Noriko Ostuka, Chiara Iodice-Kraft, Lizzy Moonga and Moritz Gutjahr

Research Institute for Regional and Urban Development, Germany

Abstract

Background:
The Horizon Europe GreenMe project defines green care through three pillars: Nature in Every Life, Nature-Based Promotion, and Nature-Based Therapy. Green care encompasses a broad range of green and blue spaces (GBS), including urban parks, gardens, cemeteries, forests, agricultural landscapes, and green corridors. While this diversity suggests that opportunities for green care are widely available, preliminary findings from stakeholder interviews indicate that many existing GBS are not designed or managed to support green care activities. Furthermore, survey responses show that some GBS are visited much more frequently than others. This study investigates the mismatch between the physical accessibility of GBS and their perceived suitability for green care by exploring the barriers and motivations that influence people's use of nature.
Methodology:
The study combines geospatial analysis, social survey data, and field audits for the case study city of Herne, Germany. An online survey was conducted to identify barriers to engaging with nature and characteristics that motivate visits to green and blue spaces (GBS), yielding more than 1,000 responses. In addition, over 60 GBS were systematically audited during the summer of 2025 to assess their environmental characteristics and quality. Spatial accessibility was evaluated using GIS-based network analysis to calculate the shortest walking distance from residential buildings to the nearest GBS.
Results:
The accessibility analysis indicates that most residents can reach a GBS within a 15-minute walk. However, survey responses reveal that two of the most frequently reported barriers are that "nowhere near me is nice enough to spend my free time" and "there is no natural space close to me." These findings suggest that physical proximity alone does not determine whether a space is perceived as suitable for green care. Many nearby GBS are not considered sufficiently attractive or natural, despite being easily accessible.
Conversely, several rural GBS attract frequent visitors despite requiring longer travel times. Survey respondents identified key qualities that motivate visits, including "the greenery on the site feels diverse and wild" and "good natural features such as trees, flower beds and ponds/lakes/rivers." These findings indicate that perceived naturalness and environmental quality are stronger drivers of visitation than proximity alone. A stronger sense of wilderness,

rich vegetation, biodiversity, aesthetic appeal, and organised activities appear to encourage people to travel further, particularly when seeking mental health and wellbeing benefits.
Conclusions:
The results demonstrate that accessibility, although widely used as a key indicator in GBS research, is insufficient for assessing the potential of green spaces to support green care. Perceived attractiveness and environmental quality play a critical role in shaping visitation behaviour. Future work will develop a gravity-based accessibility model that incorporates both accessibility and destination attractiveness. Attractiveness will be evaluated using factors such as site size, safety, vegetation quality, facilities, aesthetics, biodiversity, and organised activities, while deterrent factors will include noise, overcrowding, and a perceived lack of openness. This integrated approach aims to provide a more realistic assessment of the suitability of green and blue spaces for supporting green care interventions.

Keywords: Green care, mental health, Green and blue space, accessibility, nature based solutions

MET3: Case Studies and Quantitative Methodologies for Nature-based Solutions Integrated into Urban Infrastructure Constraints

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Restoring the Urban Water Balance: a Proxy-Based Approach to Assess Climate Adaptation Need and Nature-Based Solutions

Francesco Del Punta[1,*], Ningzhou Li[1], Hauke Sonnenberg[1], Jonas Neumann[2], Andreas Matzinger[1] and Leilah Haag[3]

[1]*Kompetenzzentrum Wasser Berlin, Germany*
[2]*RTPU Kaiserslautern-Landau, Germany*
[3]*Senatsverwaltung für Stadtentwicklung, Bauen und Wohnen, Berlin, Germany*

Abstract

Urban areas are increasingly exposed to environmental risks such as heat stress, pluvial flooding, and combined sewer overflows, all of which are intensifying under climate change and growing urbanization. Accurately modelling these processes at city scale is essential for informed planning, yet physically based models remain computationally demanding, data-intensive, and often limited to small pilot areas. In this context, water balance modelling emerges as a powerful and practical alternative, offering a simplified yet robust framework to capture the key hydrological processes governing urban environmental dynamics. This study demonstrates the value of a simplified urban water balance model (ABIMO) as a screening and diagnostic tool to assess multiple environmental risks across the entire city of Berlin. By partitioning precipitation into evapotranspiration, runoff, and groundwater recharge for more than 57,000 spatial units, the model provides a consistent and spatially explicit representation of how water is redistributed in the urban environment.

A central concept is the deviation of the urban water balance from a natural reference state (ΔW), which serves as an integrative indicator of anthropogenic alteration. The results show that this relatively simple metric correlates meaningfully with outputs from more complex physical models describing near-surface air temperature, flood volumes, and sewer overflow discharges. These correlations highlight the fundamental role of hydrological processes in shaping a wide range of environmental risks: reduced evapotranspiration contributes to urban heat islands, increased runoff amplifies flood hazards, and higher effective imperviousness drives sewer system overload.

Beyond predictive capability, the main advantage of water balance modelling lies in its efficiency, scalability, and transparency. Compared to complex model chains, it requires fewer inputs, minimal calibration, and significantly lower computational effort, making it accessible to a wider range of users, including municipalities with limited technical resources. This enables rapid, city-wide assessments that can inform early-stage decision-making, identify priority areas, and guide the allocation of resources before committing to detailed simulations. Furthermore, the conceptual simplicity of water balance components facilitates communication with stakeholders and supports interdisciplinary planning processes.

The approach is particularly well suited to the planning and evaluation of nature-based

solutions, such as green roofs, infiltration systems, and urban greening measures, as changes in ΔW consistently reflect their hydrological effectiveness and co-benefits across multiple risk domains.

Overall, this study underscores the importance of water balance modelling as a unifying and scalable tool in urban environmental assessment. While it does not replace detailed physical models, it effectively bridges the gap between data availability and planning needs, enabling a shift from localized, resource-intensive analyses to comprehensive, city-wide risk screening. By explicitly linking hydrological indicators to the performance of nature-based solutions, the approach supports more integrated and actionable strategies for climate adaptation. As this becomes an increasingly urgent priority, such simplified yet informative methods are essential for advancing resilient and water-sensitive urban planning.

Keywords: water-balance, modelling, nbs, water-sensitive urban planning, climate adaptation

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Cost/Benefit of Sustainable Resource Recovery for Urban Residuals and Chemicals Versus Structural Urban Water Treatment

John Sansalone

University of Florida, United States

Abstract

Day-to-day maintenance of urban drainage (rainfall-runoff) management systems and pavement can significantly reduce pollutant loads and benefit ecological and human health. The hypothesis that maintenance matters is quantifiable and critical for implementation of the knowledge developed in this Florida-wide (similar to Italy in geographics) data collection and research over the last decade and presented herein. The research results represent a defensible foundation to build the allocation of urban drainage load reduction credits based on maintenance practices. These maintenance practices remove gross solids (detritus), coarse particulate matter (PM) and associated constituents (such as nutrients) from the urban inventory of PM that is transported through and stored in urban drainage systems and can eventually be abraded to fine PM. This PM is a source and sink of nutrients/metals that result from the interaction and imposition of anthropogenic/biogenic activities and urban infrastructure design practices/materials on the hydrologic cycle. The fine abraded PM (< PM2.5) is ubiquitous and at high particle number in the near surface urban atmosphere that is shared by humans; with documentation demonstrating hundred of thousands premature deaths worldwide due to traffic-generated PM and the associated contaminants. This study was designed to create a Florida-based metric for PM recovery and illustrate TN and TP association with particle sizes. This study was designed to provide incentives to Florida municipalities in terms of load credits for quantifiable maintenance practices that are now implemented their regulatory basin management action plans (BMAPs) for nutrients and PM. Germaine to this study, it is noted that the results presented are a function of many variables, and while structural treatment systems (aka BMPs) BMP vendors promote differences between BMPs the reality is that such treatment and cost differences are rarely if ever significant given a lack of BMP maintenance and the benefits of urban maintenance practices. Results reinforce the knowledge that source controls or urban maintenance practices such as street sweeping can be a very cost-effective tool in reducing loads as compared to catchment-based structural BMPs. Of all the maintenance tools available to a municipality, street sweeping dominates load recovery for PM and nutrients as compared to structural treatment systems in the same urban catchments. Florida-based results indicate cost of load recovery for (TN, TP, PM) by street sweeping in $(USD) are (165.00, 257.00, 0.10) compared to structural BMP in $(USD) of (3730.00, 10500.00, 41.00); at least an order of magnitude lower than structural treatment

systems.

Keywords: Circular economy, resource recovery, particulate matter, urban maintenance, best management practices, particle size distributions, partitioning, cost-benefit, human health, cardiovascular inflammation, urban drainage

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MET4: Advancing the assessment of Nature-based Solutions for Agriculture and Food Systems within Planetary Boundaries

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An Earth System Spheres Perspective on the Integrated Assessment of Multifunctional Nature-Based Solutions

Mohammed Khalafallah, Nynke Hofstra and Ho Huu Loc

Water Systems and Global Change Earth Systems and Global Change, Wageningen University and Research, Droevendaalsesteeg 3a, 6708 PB Wageningen, The Netherlands

Abstract

Integrated assessment is increasingly recognized as essential for capturing the multifunctionality of Nature-Based Solutions (NBS), yet the extent to which current assessments represent interactions among Earth system spheres remains poorly understood. This study presents the results of a systematic review of 84 peer-reviewed studies to examine which natural processes and Earth system spheres are assessed, how these processes are integrated, and the methodological approaches adopted. The review reveals that although many studies consider processes spanning multiple Earth system spheres, genuine process integration remains limited. Nearly half of the reviewed studies (48%) assessed multiple processes without explicitly representing their interactions, highlighting a continued reliance on siloed assessment approaches. A prominent gap was identified in the representation of atmosphere–geosphere interactions. In particular, rainfall–runoff processes are predominantly modeled as a one-way relationship in which atmospheric forcing drives hydrological responses, while potential feedback of NBS on atmospheric moisture recycling and precipitation are largely neglected. These findings point to the need for assessment frameworks that explicitly account for bidirectional interactions between Earth system spheres. A preliminary result of this study explores coupling of the Wflow hydrological model with the WAM2layers atmospheric moisture tracking model to investigate how NBS may influence atmospheric moisture transport and precipitation through land–atmosphere feedback. This work aims to advance an Earth system spheres framework for integrated NBS assessment by moving beyond one-way process representations toward more holistic, process-based assessments that can better support climate adaptation and water resource management.

Keywords: Nature-based solutions, Integrated assessment, Earth system spheres, Natural processes, Atmosphere, Geosphere, Ecosphere

MET5: Nature based solutions and the role of soil life and soil ecosystem services

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Monitoring Soil Life to Support Nature-Based Solutions Within Planetary Boundaries

Bob Klein Lankhorst

Antonie, Netherlands

Abstract

Soils play a fundamental role in maintaining the Earth system by supporting biodiversity, regulating water, storing carbon and sustaining food production. These functions are central to several planetary boundaries, including biosphere integrity, land-system change, freshwater regulation and climate change. Despite their importance, soil biological processes remain poorly represented in environmental monitoring, limiting our ability to assess the effectiveness of Nature-based Solutions (NbS) and guide transitions towards more resilient landscapes.
Among soil organisms, free-living nematodes are recognised as sensitive indicators of ecosystem functioning because they occupy all trophic levels of the soil food web and respond rapidly to changes in land use and management (Ferris et al., 2001). Nematode-Based Indices (NBIs) provide internationally recognised measures of soil food-web structure, nutrient cycling and ecological resilience, offering practical proxies for soil biodiversity and ecosystem functioning (Du Preez et al., 2022). As such, they have considerable potential to support harmonised assessment of soil condition and to evaluate the ecological outcomes of Nature-based Solutions across different landscapes.
However, widespread application of nematode-based assessment has long been constrained by the time, expertise and cost associated with conventional microscopic analysis. Recent advances in automated microscopy and Artificial Intelligence (AI) now make it possible to generate standardised, reproducible and scalable measurements of soil biological quality. LIFE Monitor is one example of such an approach, enabling rapid assessment of nematode communities while creating permanent digital records that can support long-term biodiversity monitoring and future reanalysis.
By making soil biological assessment more accessible and consistent, these technologies can help bridge the gap between ecological science and practical implementation. They provide an opportunity to integrate biological indicators into monitoring frameworks that evaluate ecosystem recovery, restoration success and sustainable land management. Strengthening our capacity to measure soil biodiversity and ecosystem functioning is essential for understanding whether Nature-based Solutions are delivering their intended outcomes and for supporting evidence-based decisions that enable societies to operate safely within the planetary boundaries.

Keywords: Planetary boundaries, Nature-Based Solutions, Soil biodiversity, Ecological monitoring, Soil health, Nematodes

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MET7: Open session on methodologies for implementation and monitoring of NBS

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Dimensioning Sustainable Project Management in Productive Sectors: Strategic Alignment, Emerging Practices, and Implementation Tensions

Daniel Mateo Garzón Agudelo[1,*], Jorge Andrés Sarmiento Rojas[1] and Milton Januario Rueda Varón[2]

[1]*Pedagogical and Technological University of Colombia, Colombia*
[2]*Ean University, Colombia*

Abstract

Sustainability has become a central criterion for value creation, organizational legitimacy, and long-term performance in project management. However, despite its growing recognition in academic and professional discourse, a persistent gap remains between its conceptual acceptance and its effective integration into project decision-making. This study aims to dimension sustainable project management in productive sectors by examining its strategic alignment, emerging practices, and implementation tensions. To achieve this purpose, the research adopts a two-phase meta-aggregative literature review based on a corpus of 127 scientific articles. The first phase develops a qualitative meta-aggregation focused on extracting explicit evidence from the literature and organizing it into interpretive categories. The second phase complements this interpretation through quantitative corpus analytics, including bibliometric characterization, principal component analysis, latent Dirichlet allocation topic modeling, semantic network analysis, clustering, and association rule mining.
The qualitative findings show that sustainability is redefining the traditional notion of project success. Rather than being limited by scope, time, and cost, success increasingly depends on projects' capacity to generate economic, social, and environmental value throughout and beyond their life cycle. This transformation requires sustainability to be embedded from early project stages, particularly in formulation, business case development, stakeholder engagement, procurement, monitoring, and post-closure evaluation. The evidence also indicates that sustainability becomes operational only when it is aligned with strategic objectives and governed by mechanisms. In the absence of clear decision criteria, accountability structures, and organizational capabilities, sustainability tends to remain declarative, symbolic, or restricted to compliance and reporting.
The quantitative results confirm the systemic and fragmented nature of the field. The topic model identified twelve latent topics with a moderate-high document-topic entropy of 0.74, indicating that most documents activate several dimensions simultaneously. Similarly, the principal component analysis retained seven components explaining 27.24% of the accumulated variance, reflecting a highly dispersed and multidimensional corpus. Although consolidated thematic nuclei were found around project management, governance, project

success, and organizational capabilities, other domains remain weakly integrated. In particular, risk management, sustainability metrics, financial decision-making, circular economy, and regenerative approaches appear as relevant but underdeveloped areas. The clustering analysis further distinguishes between a more cohesive disciplinary cluster focused on governance, success, and implementation barriers, and a broader applied cluster characterized by sectoral dispersion across agriculture, production systems, digital technologies, and value chains.

The triangulation between qualitative and quantitative results reveals three main insights. First, sustainable project management has achieved high theoretical legitimacy, but its operational integration remains uneven. Second, the field has advanced significantly in measurement, indicators, ESG frameworks, digital traceability, and reporting systems, yet these instruments do not necessarily transform project selection, investment, prioritization, or control decisions. Third, sustainability is not merely a technical issue; it depends on organizational culture, ethical leadership, stakeholder management, communication, learning capabilities, and the capacity to balance competing short- and long-term interests.

The study concludes that the main challenge for sustainable project management is not the absence of tools, frameworks, or conceptual development, but the misalignment between what organizations recognize as important, what they are able to measure, and what they actually incorporate into their decisions. Therefore, future research and practice should strengthen the connection between sustainability metrics, risk analysis, financial evaluation, governance structures, circular economy models, and strategic decision-making. Sustainable project management will only move from an aspirational discourse to a transformative managerial logic when sustainability becomes a binding criterion for value creation, accountability, and project governance across productive sectors. This contribution provides an integrated reading of the field and offers a basis for advancing future empirical studies, managerial models, and sectoral interventions aimed at closing the persistent gap between sustainability discourse and sustainable project practice in complex contemporary productive environments.

Keywords: Sustainable project management, Strategic alignment, Project governance, Circular economy, Sustainability metrics

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Al-Marri, M.; Pinnington, A.H. Managing Sustainability

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A Decision-support Workbench for Evidence-based Siting of Nature-based Solutions With Integrated Environmental, Economic, and Social Benefit Assessment

Estifanos Addisu Yimer[1,*], Ann Van Griensven[1], Jiri Nossent[2] and Tom D'Haeyer[3]

[1]*Vrije Universiteit Brussel, Belgium*
[2]*Flanders Hydraulic, Belgium*
[3]*Irrawaddy Earth, Belgium*

Abstract

Nature-based Solutions are increasingly central to climate adaptation and biodiversity strategies, yet their on-the-ground deployment remains constrained by ad-hoc siting decisions that lack transparency, reproducibility, and defensible weighting of competing criteria. Equally lacking are frameworks that move beyond biophysical suitability to quantify the bundle of co-benefits such as environmental, economic, and social that justify investment in these interventions. Practitioners need tools that translate the literature on where each Nature-based Solution works, and what it delivers, into spatially explicit recommendations a planner can defend to stakeholders. We present a decision-support automated workbench that integrates the Analytic Hierarchy Process with geospatial multi-criteria decision analysis for thirteen Nature-based Solution types, spanning wetlands, riparian buffers, floodplain restoration, urban green infrastructure, and the Managed Aquifer Recharge family. For each intervention, the tool ingests biophysical and socio-hydrological layers including elevation, land use, soil, groundwater depth, aquifer recharge, precipitation, evapotranspiration, population density, river network proximity, organic carbon, and height-above-nearest-drainage-derived flood depth. There are reclassified onto a common suitability scale, and combines them through Analytic Hierarchy Process weights whose Consistency Ratio is verified at every run. Each suitable site is then evaluated against a literature-derived benefit profile that quantifies environmental co-benefits (carbon sequestration, biodiversity, water quality, flood regulation), economic returns (avoided damages, ecosystem service valuation, implementation cost), and social outcomes (community access, recreational value, public health). The framework has been demonstrated in Flanders (North of Belgium) and is transferable to any region with comparable input layers, offering a defensible bridge between Nature-based Solution theory and planning practice across diverse climatic and socio-economic contexts.

Keywords: Suitability mapping, Socio-economic benefits, Ecosystem co-benefits, Spatial decision-support, digital transformation

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Evaluating High-Resolution Geomorphometry and UAV-Derived Spectral Indices for Environmental Monitoring and Nature-Based Solutions Diagnosis

Jesús Rodrigo-Comino[1,*], Víctor Rodríguez-Galiano[2], Francisco Serrano Bernardo[1], Clemente Irigaray[1], Jesús Fernández-Gálvez[1], Andrés Caballero-Calvo[1] and Víctor Hugo Durán Zuazo[3]

[1]*University of Granada, Spain*
[2]*University of Seville, Spain*
[3]*IFAPA, Camino de Purchil, Granada, Spain*

Abstract

Advanced remote sensing techniques are essential for diagnosing environmental degradation problems and establishing baseline assessments for Nature-based Solutions (NbS) in vulnerable Mediterranean ecosystems. However, the high-resolution performance of Unmanned Aerial Vehicle (UAV) metrics remains sensitive to extreme environmental variations and seasonal crop management practices. This study examines the structural and spectral sensitivity of UAV data under complex agricultural and geomorphological scenarios in southern Spain. First, the operational limits of visible spectral indicators were tested under conditions of severe canopy degradation in a harvested cereal field. Comparing RGB indexes (ExG, ExR, VARI, and GLI) against multispectral NDVI revealed very weak linear correlations (Pearson $r < 0.15$), confirming that visible-band proxies become unreliable for environmental stress assessment when green biomass is minimal and dry soil residue dominates. Second, an integrated geomorphometric and machine learning (Random Forest) approach was utilized to dissect terrain controls on surface spectral variability. Topographic slope (29% importance) and radiative exposure (eastness) emerged as key drivers of soil moisture and microtopographic reorganization. Finally, a GIS-based multivariate framework incorporating Principal Component Analysis (PCA) successfully tracked short-term structural reconfigurations within erosive gully landscapes after high-magnitude convective rainfall events, such as the 2024 DANA. Results demonstrate that while vegetative indices compress under heavy post-harvest or degraded states, multi-scale local relief models combined with AI diagnostic regressions provide an objective workflow to pinpoint landscape connectivity and soil erosion hotspots. This integrated methodology is crucial for designing, monitoring, and validating targeted NbS soil-preservation interventions.

Keywords: Cereals, remote sensing, UAV, geomorphometry, geomatics

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Scale Matters: Key Regional Research and Innovation Needs to Support Soil Health Living Labs

Saskia Keesstra[1,*], Niels Halberg[2], Laura Nouges[3], Sabine Jordan[4], Amanda Matson[1] and Linda Maring[3]

[1]*Wageningen Environmental Research, Droevendaalsesteeg3 6708PB, Wageningen, The Netherlands*
[2]*Aarhus University, Nordre Ringgade 1, 8000 Aarhus, Denmark*
[3]*DELTARES Pobox 85467, 3508 AL Utrecht, The Netherlands*
[4]*Swedish University of Agricultural Sciences Box 7014, 75007 Uppsala, SWEDEN*

Abstract

To support future development of Soil Health Living Labs (LLs) in Europe an assessment of regional research and innovation (R&I) needs was assessed. LLs are collaborative spaces for co-creating solutions to regional soil challenges in a real-life setting, engaging multiple stakeholders in science, policy, and practice. Soil health is vital to tackling climate change and socio-economic challenges, requiring region-specific solutions. The regional R&I needs to elevate soil health group around four areas: (1) scientific research, (2) co-created innovation, (3) data and monitoring, and (4) upscaling practices. These needs are categorized into general European priorities, land-use-specific needs (agriculture, forestry, urban, and mixed-use areas), and regional differences (North-, South-, East-, and West-Europe). Overarching R&I needs include clearer soil health definitions, improved models of soil processes, and cross-sectoral integration. Innovations should provide decision-support tools and secure long-term financing for LLs. Monitoring must use harmonized, cost-effective methods, while upscaling efforts require acknowledgement of regional differences, improved soil literacy and removal of institutional and financial barriers.

In agriculture, challenges range from sustainable cropping systems to soil biology assessments and landscape-level planning. Regional agricultural priorities include water management and peatland restoration in the North, erosion and drought adaptation in the South, regenerative farming in the West, and organic practices in the East. Forestry-focused needs include adapting strategies to long rotation cycles, fostering collaboration between stakeholders, and enhancing data and risk models. Northern forests require better carbon-focused management, the Southeast needs awareness on tourism impacts, Western regions should focus on peatland restoration and biomass, and Eastern areas on mixed forests and soil infrastructure. Urban and (post)industrial regions must address soil sealing, contamination, and restoration. This includes developing pollution maps, improving public awareness, and integrating soil considerations into urban planning. Challenges are largely consistent over the regions, but some points of attention were highlighted: Northern cities face compaction, Eastern regions need contamination research, Southern areas deal with soil degradation,

especially erosion, and Western Europe must align policies for urban growth and nature/soil conservation. Mixed and transitional land use areas, such as abandoned land, peri-urban zones, and touristic regions, require tailored strategies addressing unique pressures on soil health.

Key barriers to LLs implementation include funding, institutional support, technical capacity, and soil literacy. Co-creation is challenged by limited awareness, while practice implementation faces logistical and socio-economic hurdles. Solutions include sustained funding, multi-level policy coherence, and landscape-scale planning. Looking ahead, three strategic directions are recommended: (1) ensuring long-term funding to support the iterative nature of LLs and stakeholder trust-building; (2) enhancing policy coherence across agriculture, environment, and climate sectors, including matching public-private financing; and (3) adopting a landscape and food system approach to address soil health across ecosystems and communities. These strategies aim to foster a shift toward sustainable soil management practices, essential for climate resilience and socio-economic stability across Europe.

Keywords: Co-creation, Regional Needs, Sustainable Management, Policy Coherence, Soil Health, ecosystem services Living Labs

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Nature-Based Solutions for Wildfire Risk Mitigation in Europe: a Comparative Analysis of Northern and Southern Case Studies and Barriers to Scaling

Saskia Keesstra[1,*], Artemi Cerda[2], Antonio Gimenez Morero[3], Diego Gamiz Monterde[2], Giulia Salvini[1] and Bertram de Rooij[4]

[1]*Wageningen Environmental Research, Droevendaalsesteeg3 6708PB, Wageningen, The Netherlands*
[2]*Soil Erosion and Degradation Research Group. Departament de Geografia; Universitat de València; Av. Blasco Ibáñez, 28; 46010 Valencia, Spain*
[3]*Departamento de Economía y Ciencias Sociales, Escuela Politeècnica Superior de Alcoy, Universidad Politécnica de Valencia. Plaza Ferrandiz y Carbonell s/n, 03801 Alcoy, Alicante, Spain*
[4]*Wageningen Environmental Research, Droevendaalsesteeg3 6700PB, Wageningen, The Netherlands*

Abstract

Wildfire risk is increasing across Europe as climate change interacts with land-use change, ecological degradation, drought, and expanding wildland–urban interfaces. While wildfire governance has historically focused on suppression and emergency response, growing attention is being directed toward preventive and landscape-based approaches that reduce underlying drivers of risk. Nature-Based Solutions (NBS) have emerged as a promising strategy to enhance wildfire resilience by modifying ecological processes, reducing fuel continuity, improving hydrological conditions, and strengthening broader ecosystem functioning. However, comparative evidence on how these approaches operate across different European contexts remains limited.

This paper examines how Nature-Based Solutions contribute to wildfire risk reduction in contrasting bioclimatic and governance settings through a comparative qualitative case study analysis of the Deurnsche Peel in the Netherlands and the Valencian Community in Spain. Drawing on case study reports developed within the ReAdapt project, the analysis combines literature review, stakeholder engagement, field-based insights, and cross-case synthesis to examine NBS effectiveness, governance arrangements, financing mechanisms, and barriers to implementation and scaling.

The findings demonstrate that NBS can support wildfire resilience through multiple pathways, but that their effectiveness is strongly context dependent. In the Valencian case, where wildfire risk has long been recognised, preventive interventions such as prescribed burning, green firebreaks, fuel management, grazing, and landscape mosaics show clearer evidence of reducing fuel loads, fire intensity, and wildfire spread. In contrast, the Deurnsche Peel illustrates an emerging wildfire context in which interventions including peatland restoration,

rewetting, compartmentalisation, and vegetation management contribute more indirectly to wildfire prevention through hydrological restoration and ecosystem resilience.

Despite these regional differences, both cases demonstrate that NBS generate broader co-benefits including climate adaptation, biodiversity enhancement, water regulation, and strengthened territorial resilience. At the same time, implementation remains constrained by fragmented governance, sectoral policy silos, institutional capacity limitations, short-term funding structures, and challenges in translating technical knowledge into long-term institutional commitment.

The paper argues that scaling NBS requires moving beyond isolated pilot projects toward integrated, multi-level governance approaches that embed wildfire prevention within climate adaptation, spatial planning, and landscape management. By comparing northern and southern European experiences, this study contributes to the growing evidence base supporting preventive, landscape-oriented strategies and provides recommendations for strengthening European adaptation policy and long-term wildfire resilience.

Keywords: Landscape resilience, Preventive management, Multi-level governance, Climate adaptation, Territorial planning

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Assessing Performance of Constructed Wetlands With High-frequency Sensors to Guide Effective Mitigation of Diffuse Agricultural Pollution

Brandon C. Goeller[1,*], Lucy A. McKergow[2], Alex Vincent[2] and Chris C. Tanner[2]

[1]*Earth Sciences New Zealand, Whakatu – Nelson, Aotearoa, New Zealand*
[2]*Earth Sciences New Zealand, Kirikiriroa – Hamilton, Aotearoa, New Zealand*

Abstract

Quantifying field-scale treatment --performance of constructed wetlands (CWs) is essential to guide cost-effective implementation and accurately account for their contaminant load reductions in nutrient budgets and environmental plans for farms and catchments. Following the development of new guidelines for practical application of on-farm CWs in New Zealand in 2022, we sought to assess their real-world performance intercepting mixed surface and groundwater inflows across a range of agricultural landscapes. Working in partnership with councils, industry, and farmers, co-funded by the NZ Ministry for Primary Industries, we undertook comprehensive monitoring of flow and water quality over 2-4 year periods at the inflows and outflows of 4 newly established CWs. The wetlands were sized at 1.2 to 2.7 % of their contributing catchments and constructed in accordance with the new guidelines. Additional groundwater monitoring was undertaken where water balances showed significant anomalies. We used a range of modelling tools to estimate high frequency time-series for nitrogen, phosphorus, sediment and faecal microbes and quantify annual mass loads, load reductions and efficiency for each wetland. The annualised load reductions for TN, TP, SS and E. coli are reported and compared against guideline predictions. We chart the pathway and the challenges in developing and testing the guidelines and demonstrating the potential of CWs as nature-based mitigation tools. This has enabled industry and rural professionals to confidently promote their use and provided assurance for government to reduce regulatory hurdles and allow farmers to claim CW nutrient reductions in their farm environmental plans to achieve catchment nutrient targets.

Keywords: wetlands, contaminants

SO1: More than Green - Towards more just, inclusive NBS reflecting socio-cultural and socio-economic aspects

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Operationalizing Environmental Justice and Voicing Nature – a Reflexive Ethics Framework for Inclusive Nature-Based Solution Practices in the TRANS-lighthouses Project

Eduardo Mendes[1], Gerd Lupp[2,*], Andreia Barbas[3], Joana Santos[3] and Isabel Ferreira[3]

[1]*Câmara Municipal de Estarreja (Portugal), Portugal*
[2]*TUM School of Life Sciences, Chair for Strategic Landscape Planning and Management, Technical University of Munich, Germany*
[3]*Centre for Social Studies, University of Coimbra, Portugal*

Abstract

An increasingly important aspect of Nature-Based Solutions (NBS) and nature restoration efforts is seen in their potentials to create “more than green” solutions to address socio-environmental issues, enhance human well-being and support inclusion of stakeholders and citizens in co-creation processes of NBS. In this way, they are cornerstones of ambitious high-level political goals and targets set such as the EU Green Deal and international commitments such as halting the loss of biodiversity or mitigating and adapting to changing climate.
Looking at the challenges related to such goals and meaningful processes to achieve them, ethical questions arise regarding how to support establishing new human–nature relations, to ensure environmental justice and achieve sustainability governance. The ambition of the TRANS-lighthouses project is to meaningfully give voice to nature, foster care for ecosystems, and support a shift in human–nature relations by integrating diverse ethical worldviews and knowledges when co-creating NBS.
Working with a participatory action research approach and epistemologies of co-creation processes, conceptualizing ethics in TRANS-lighthouses is more than just setting a normative framework or a necessity when working with stakeholders. Indeed, it is one of the core elements embedded within the research-in-action practices and co-evolving withing the co-creation process of NBS. The backbone of the ethical framework is structured around the project’s four conceptual dimensions participatory governance, social, human-nature, and economic aspects. Reflecting the co-creation approach from the very beginning along the four dimensions to structure the work, for each dimension, across the consortium, in a series of workshops and reflexive monitoring exercises, we co-formulated key ethical questions that arise and related challenges to them. Based on these reflections, we co-elaborated the corresponding strategies and guiding principles for the work in TRANS-lighthouses.
For the human-nature dimension, we conceptualise ethics as relational, context-dependent, and inherently political. With the ambition of finding pathways for transformation and moving towards a more holistic, beyond human-centric perspective, nature should not be treated as a resource for delivering ecosystem services. Instead, for the human-nature dimension, the

framework centres the intrinsic value of ecosystems and fosters for regenerative, care-oriented human–nature relations. Key ethical issues to be reflected in collaborative efforts is to actively avoid and alway reflect, if, despite well meant ideas, activities and processes, anthropocentric and extractivist paradigms in NBS co-creation processes are unintentionally reinforced, nature and potential NBS might again be judged through a market-oriented NBS lens, or co-creation processes and suggested NBS lead to social exclusion, that would, in consequence, undermine the intended “more than green” approach.

To address these issues, the framework sets up ethical principles and strategies centred around ecological integrity, intergenerational justice, and the recognition of nature as a co-constitutive actor in socio-ecological systems. Thus, co-creating NBS must integrate the EU “Do No Significant Harm” principle and must be aligned with strong sustainability principles, accept ecological limits, and critically reflect growth-oriented paradigms.

Reflecting ethics and creating a structured ethical framework by giving intrinsic value to nature including reflexion and reflexive moments in NBS co-creation approaches can help to support more balanced, more ethical just, more resilient co-creation processes and implementation of mroe meaningful NBS that reconnect people with nature and support environmental citizenship.

Keywords: Nature Based Solutions, Ethics, Human-Nature Relation, Environmental Justice

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Climate Justice in Interventions Within Protected Areas in the Caulim Basin (São Paulo, Brazil): a New Paradigm?

Isabela Carmo Cavaco[1,*], Pedro Roberto Jacobi[1] and Luciana Rodrigues Fagnoni Costa Travassos[2]

[1]*University of São Paulo, Brazil*
[2]*Federal University of ABC, Brazil*

Abstract

Since 2010, Brazil's urban planning policies have shifted toward a greater focus on the environmental management of the territory, moving away from the previous reliance on engineering-based standards—particularly regarding drainage and flood control works on urban rivers (Travassos, 2010). Against this backdrop, and considering the concept of climate justice (Torres et al., 2021)—which is gaining traction within social movements and public policy by highlighting the political and ethical dimensions of climate change impacts—this study aims to examine whether a climate justice perspective is present in the urban planning policies of the city of São Paulo, such as the Municipal Climate Action Plan. This analysis is conducted through the monitoring of "Territórios da Água", a Public Policy Research Program established through a partnership between the city of São Paulo, the Federal University of ABC (UFABC), and the National Observatory for the Rights to Water and Sanitation (Ondas). This ongoing doctoral research within the University of São Paulo's Postgraduate Program in Environmental Science, addresses the gap of the dialogue between the use of climate justice in policies and discourses and the lowest level of territorial planning, which are the projects. The projects focused are those of interventions in environmentally protected areas occupied by peripheral populations in the city of São Paulo, in the Caulim River basin. This watershed is situated between the São Paulo Metropolitan Area's two largest water reservoirs: the Guarapiranga and Billings reservoirs. This study analyzes news, public announcements, and conducts a documentary analysis of urban and environmental planning policies from the agencies involved in the Territórios da Água project (including the departments of environment, housing, and urban infrastructure and public works, as well as the São Paulo State Basic Sanitation Company (Sabesp), among others) to investigate their use of the climate justice concept. Content analysis will be performed with the obtained dataset. The central hypothesis is that, although urban and environmental planning policies may establish climate justice as a guiding principle, and interventions in environmentally protected areas occupied by marginalized populations sometimes incorporate climate adaptation techniques—such as Nature-Based Solutions—climate justice is not genuinely considered in terms of the intersections of race, gender, and class, nor across the various dimensions of justice (distributive, procedural, recognition-based, and corrective) (Sultana, 2021; Schlosberg et al., 2024). Preliminary results show that there is a recent use of the climate justice concept in

policies and discourses of the public authorities. Still, the ongoing urban interventions in the Caulim basin perpetuate functionalist paradigms instead of mixed-use interventions that prioritize the environment and integration with the communities' way of life, which contributes to climate injustices.

Keywords: climate justice, territorial planning, urban planning, public policy

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SO2: Transforming Agriculture for Climate, People and Planet: Pathways from Demonstration to Systemic Change

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Between Heritage and Climate Crisis: Agricultural Identity, Adaptive Hybridisation, and Structural Constraints Among Smallholder Farmers in Lower Dir, Khyber Pakhtunkhwa, Pakistan

Mujeeb Ur Rahman

Quaid I Azam University Islamabad, Pakistan

Abstract

Despite growing scholarship on climate change and agriculture in Pakistan, the socio-cultural, psychosocial, and structural dimensions of smallholder adaptation remain underexplored. This qualitative study examines how farmers in Lower Dir, Khyber Pakhtunkhwa (KP), adapt their agricultural practices socially to climate change, taking into account Pakhtun cultural identity, traditional ecological knowledge (TEK), psychosocial wellbeing, and institutional constraints. Guided by an interpretivist paradigm and grounded in Cultural Ecology (Steward, 1955) and Social Adaptation Theory (Bourdieu, 1977, 1984; Adger, 2003), the study employed open-ended, in-depth interviews with 21 purposively selected farmers (minimum 35 years' experience), analysed through Braun and Clarke's (2006) six-phase thematic analysis, yielding nine core themes. Agriculture in Lower Dir is constitutive of Pakhtun social identity, anchored in land ownership, Pakhtunwali, and intergenerational duty, and climate change, manifesting as erratic rainfall, shortened seasons, and destructive floods, disrupts this identity as profoundly as it disrupts production, generating epistemic grief and psychosocial suffering overlooked in existing literature. Adaptation is neither a linear transition to modern farming nor an abandonment of ancestral knowledge; it is a dynamic process of adaptive hybridisation in which TEK and modern tools coexist in productive tension. Structural barriers, financial exclusion, infrastructure deficits, poorly calibrated extension services, and systematic gender exclusion constrain adaptive capacity more severely than knowledge deficits. Three theoretical contributions are made: Bourdieu's habitus and field are extended into climate adaptation; adaptive hybridisation is introduced as a concept distinct from technology diffusion; and structural inequity, through four reinforcing conditions unique to Lower Dir, is identified as the primary adaptive constraint.

Keywords: climate change adaptation, TEK, Pakhtunwali, agrarian identity, adaptive hybridisation, psychosocial wellbeing, qualitative research, Khyber Pakhtunkhwa

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SO3: Open session on science-society: Bridging Science and Society for the Implementation of Nature-Based Solutions

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Bridging Science and Landowner Decision-making Through a Serious Game for Nature-based Solutions

Jan Macháč[1,*], Lenka Slavíková[1] and David Ellerbrake[2]

[1]*J. E. Purkyne University in Usti nad Labem, Czech Republic*
[2]*TU Dortmund; University of Hamburg, Germany*

Abstract

The implementation of nature-based solutions (NbS) often depends on decisions made by private landowners. Their willingness to participate is shaped not only by economic incentives, but also by trust, perceived fairness, administrative complexity, local knowledge, property rights and long-term uncertainty. Although scientific evidence on the benefits of NbS is increasingly robust, translating this knowledge into practice requires tools that support dialogue between researchers, public authorities, practitioners and landowners.
This contribution presents a serious game developed within the Horizon Europe project Land4Climate. The game is designed to explore how private landowners perceive different policy and economic instruments supporting NbS implementation. It simulates land-use decision-making in climate adaptation contexts and allows participants to compare instruments such as subsidies, payments for ecosystem services, land swaps, compensation mechanisms and biodiversity offsets. By combining role-based decision-making with structured reflection, the game creates a space for transdisciplinary learning and discussion about barriers, motivations and enabling conditions for NbS.
The presentation builds on results from game sessions conducted in Czechia and Slovakia, including sessions with real landowners in Krásná Lípa and Košice region, as well as previous testing with students at TU Dortmund. The findings indicate that landowners' decisions are influenced by a combination of financial feasibility, clarity of responsibilities, perceived legitimacy of proposed measures, administrative burden and confidence in public institutions. Compared with student-based testing, sessions with landowners brought more attention to practical implementation details, long-term maintenance, ownership constraints and scepticism towards institutional promises.
The serious game demonstrates how participatory and educational tools can strengthen the science-society interface in NbS implementation. Rather than simply communicating scientific knowledge, the game facilitates learning through role reversal, productive conflict and structured reflection. This gives rise to a more entangled relationship between ownership interests, local knowledge and the treatment with environmental risks. Researchers gain a deeper understanding of landowners' concerns, while participants explore the potential benefits, trade-offs and governance challenges of NbS. The contribution therefore highlights the value of serious games as instruments for capacity building, stakeholder engagement and co-creation in climate adaptation planning.

Keywords: nature-based solutions, serious game, private landowners, science-society interface, climate adaptation

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Bridging the Gap Between Science and Practice: the Role of Practice-based Education in Accelerating Sustainable Soil Management

Gera van Os, Karin Pepers and Christian de Kleijn

Aeres University of Applied Sciences, 8250 AJ Dronten, Netherlands

Abstract

Preserving and improving soil quality is essential for achieving societal goals related to climate, food security and safety, biodiversity, and water quality. The Dutch government aims for all agricultural soils to be managed sustainably by 2030. Achieving this requires action not only from (future) farmers but also from advisors, suppliers, and other stakeholders throughout the agricultural supply chain.
The main threat to soil health on Dutch mineral soils is subsoil compaction. Nearly 50% of fields are affected below the furrow, reducing plant growth, water regulation, carbon sequestration, and soil biodiversity. While many farmers recognize the need to improve soil quality, measuring and interpreting soil health indicators remains challenging. As soil quality, water quality, and climate objectives are closely interconnected, effective soil management requires field-specific advice that accounts for both synergies and trade-offs.
To promote consistent, evidence-based soil management advice, Aeres University of Applied Sciences (UAS), commissioned by the Dutch government and agricultural service providers, developed a training program for soil advisors focusing on integrated, sustainable soil management and nature-based solutions. Participants also contribute to applied research by testing innovative advisory tools and methods for assessing soil health. Several course topics are available online through the NBSoil Academy [1].
Nature-based solutions to improve soil health in general include cover crops, reduced tillage, greater crop diversity, and organic amendments such as compost. Recent studies also demonstrate the potential of adding clay to sandy soils (LIFE CO2SAND [2]), while the combined use of compost, clay, and cover crops producing biological nitrification inhibitors is being investigated in the ClipMicro project [3].
Despite extensive scientific knowledge, adoption in practice remains limited. Farmers may be unaware of soil quality issues, innovations can be difficult or costly to integrate into farm management, and policy-driven innovations increasingly face resistance. In the Netherlands, societal polarization has increased farmers' mistrust of government-funded science, reducing their willingness to participate in research.
This presentation illustrates how Aeres UAS bridges the gap between science and practice through practice-based research involving students. Case studies show how students — many with farming backgrounds and access to farmer networks — often obtain richer insights

through informal discussions with farmers than academic researchers. Their involvement also strengthens their understanding of the value of research and its role in addressing societal challenges.
This approach demonstrates how practice-based education and student involvement can strengthen trust, improve knowledge exchange, and accelerate the adoption of sustainable soil management practices.

Keywords: Soil advisors, student research, soil health, nature-based solutions, knowledge exchange

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The Role of Science in Biodiversity Regulation

Prof. Dr. Birgit Peters

Universität Trier, Fachbereich V - Rechtswissenschaften, Germany

Abstract

It is long established that the natural sciences play a role in the regulation of environmental matters. Biodiversity is no difference. However, in current biodiversity science, high throughput measures and big data create a bulk of insights that biodiversity regulation still needs to process. They allow more holistic views, and predictions of future ecosystem developments. Their inclusion requires standardization processes as well as technological equipment, supplies and relevant know-how. In addition, the methods need to be reconciled with standard biodiversity monitoring as well as insights gained from traditional knowledge. This contribution identifies challenges to the inclusion of new methods, it reviews ways in which biodiversity law has allowed taking new scientific insights on board and identifies procedures that allow dealing with the plethora of insights that result from their combination.

Keywords: ecosystems, holistic view, biodiversity monitoring, law

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