PHUSICOS: ‘According to nature’

Nature-based solutions in rural mountain areas

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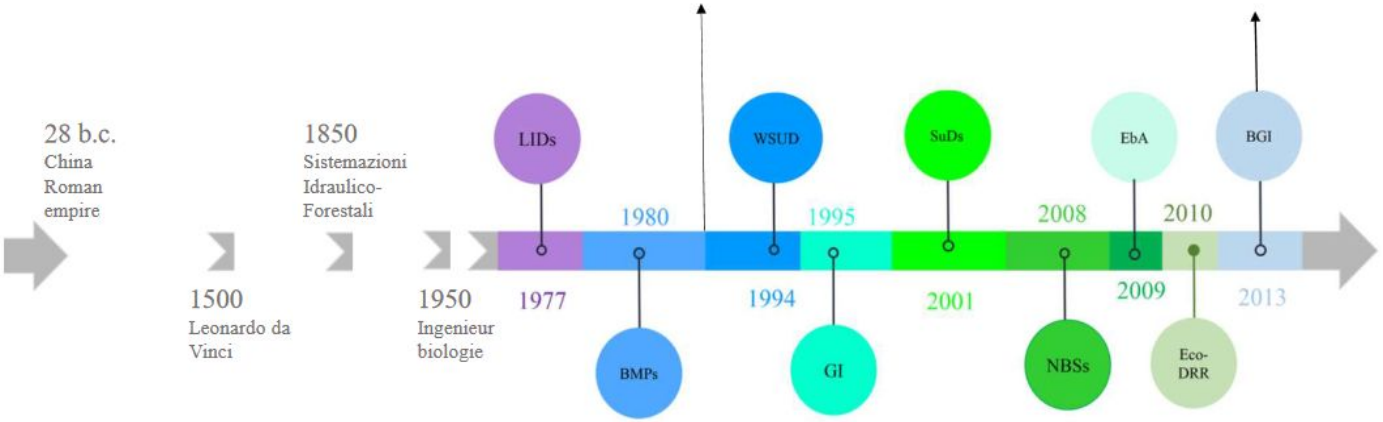
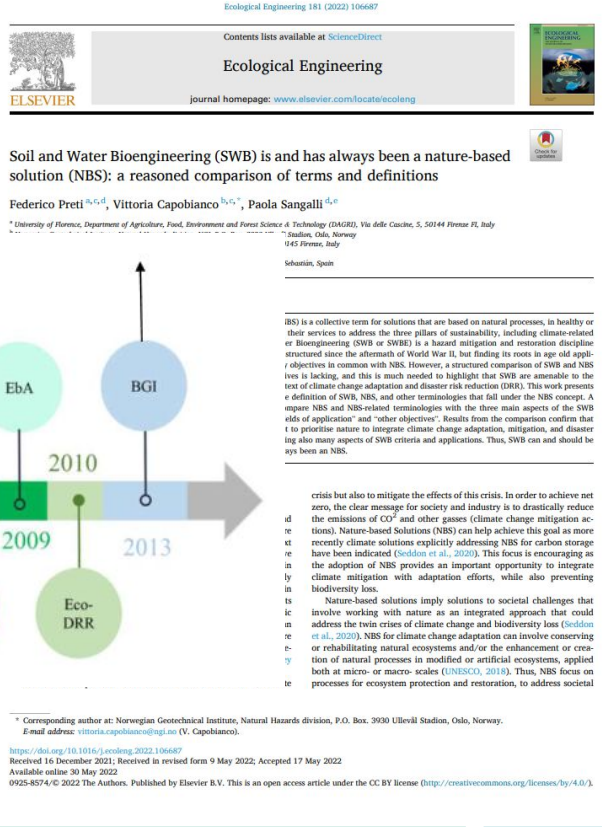
Definition of nature-based solutions

- Solutions "inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience" (EU, 2015).
- "Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions." *
- Nature-based solutions must therefore benefit biodiversity and support the delivery of a range of ecosystem services. *

* https://ec.europa.eu/info/research-and-innovation/research-area/environment/nature-based-solutions_en

Definition of NBS as an umbrella concept that builds on various disciplines





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Soil and Water Bioengineering (SWB) is and has always been a nature-based solution (NBS): a reasoned comparison of terms and definitions

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iBS) is a collective term for solutions that are based on natural processes, in healthy or their services to address the three pillars of sustainability, including climate-related er Bioengineering (SWB or SWBE) is a hazard mitigation and restoration discipline structured since the aftermath of World War II, but finding its roots in age old appli- / objectives in common with NBS. However, a structured comparison of SWB and NBS ives is lacking, and this is much needed to highlight that SWB are amenable to the text of climate change adaptation and disaster risk reduction (DRR). This work presents e definition of SWB, NBS, and other terminologies that fall under the NBS concept. A mpare NBS and NBS-related terminologies with the three main aspects of the SWB elds of application" and "other objectives". Results from the comparison confirm that t to prioritise nature to integrate climate change adaptation, mitigation, and disaster ng also many aspects of SWB criteria and applications. Thus, SWB can and should be ays been an NBS.

crisis but also to mitigate the effects of this crisis. In order to achieve net zero, the clear message for society and industry is to drastically reduce the emissions of CO^2 and other gasses (climate change mitigation actions). Nature-based Solutions (NBS) can help achieve this goal as more recently climate solutions explicitly addressing NBS for carbon storage have been indicated (Seddon et al., 2020). This focus is encouraging as the adoption of NBS provides an important opportunity to integrate climate mitigation with adaptation efforts, while also preventing biodiversity loss.

Nature-based solutions imply solutions to societal challenges that involve working with nature as an integrated approach that could address the twin crises of climate change and biodiversity loss (Seddon et al., 2020). NBS for climate change adaptation can involve conserving or rehabilitating natural ecosystems and/or the enhancement or creation of natural processes in modified or artificial ecosystems, applied both at micro- or macro- scales (UNESCO, 2018). Thus, NBS focus on processes for ecosystem protection and restoration, to address societal

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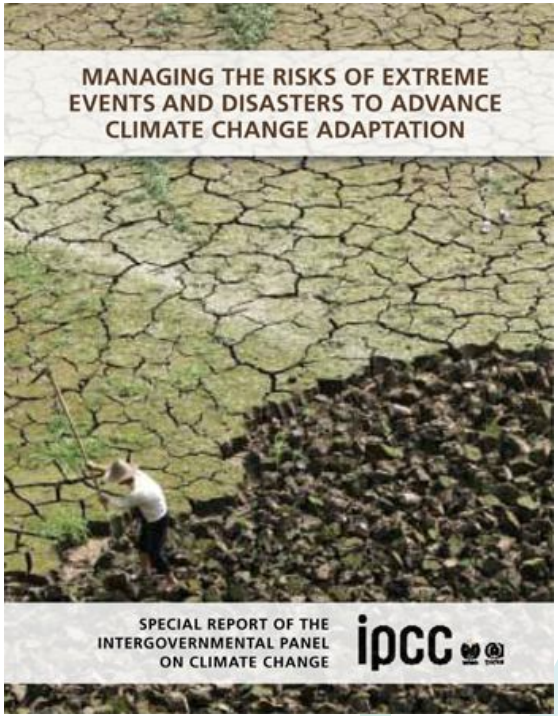
Natural hazard risks from extreme weather events

- Damage costs from extreme weather events (floods, droughts, landslides, storm surges) are very high, and increasing.
- Impact from climate change and other changes (land use change, demography) are likely to worsen the situation.
- Traditional engineering concepts are costly, take space, lack flexibility, and may have negative impact on ecosystems.
- Nature-based solutions are available on small-scale level but need upscaling.



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EU HORIZON 2020 Innovation Action (2018-2023) to demonstrate the implementation of nature-based solutions to reduce the risk of extreme weather events in rural mountain landscapes:

- The impacts of extreme hydro-meteorological events in mountain areas often affect entire river basins (flooding and landslides)
- Extreme weather events trigger rapid-moving mass gravity flows
- Managing water issues can help manage landslide and debris flow hazards downstream.
- Mountainous regions do not receive same attention as urban areas.

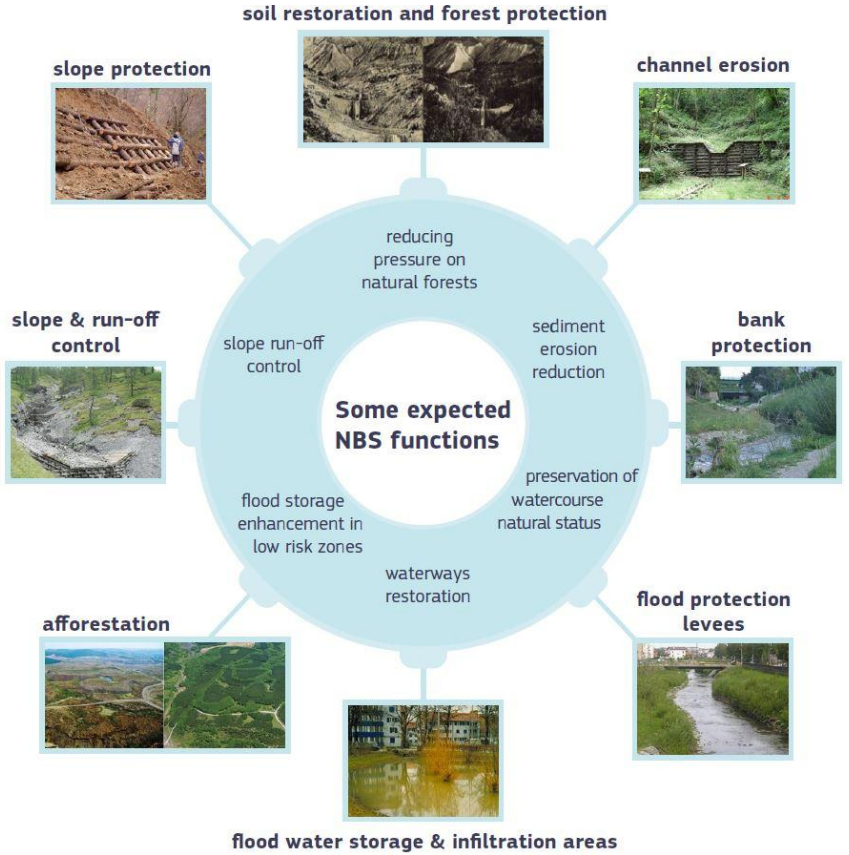
Illustration: The Norwegian Water Resources & Energy Directorate

NBS for reduction of landslide hazard

- Lack of adequate proof-of-concept for the ability of NBSs to mitigate the risk of hydro-meteorological events in sensitive rural and mountainous regions is a challenge.
- ‘Nature-Based Solutions and Re-Naturing Cities' listed over 300 potential measures that could be applied when constructing NBSs; however, only 50 measures were specifically related to DRR and only one addressed the risk in mountainous regions and landslide hazards (Sutherland et al., 2014).
- There is a significant potential for innovation in this area.
- Often the NBS for landslide hazard mitigation should be combined with “grey” mitigation measures to be effective.

NBS examples for slopes and riverbanks

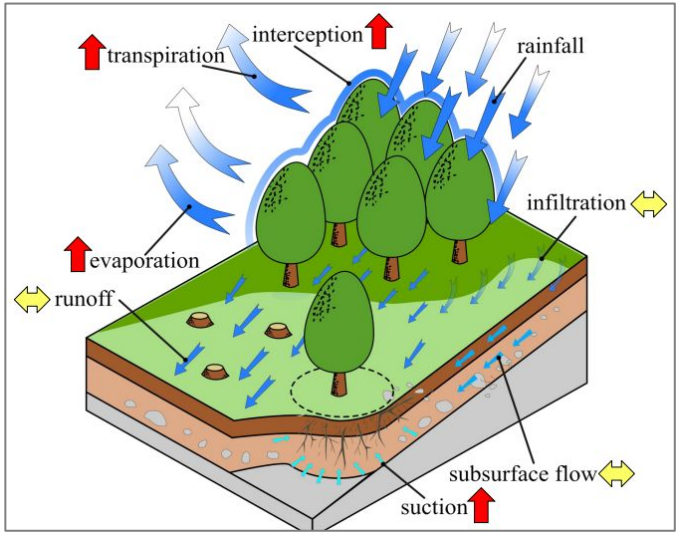
- Soil restoration and forest protection
- Slope protection
- Channel erosion
- Slope & runoff control
- Afforestation
- Flood water storage and infiltration areas
- Flood protection levees
- Bank protection



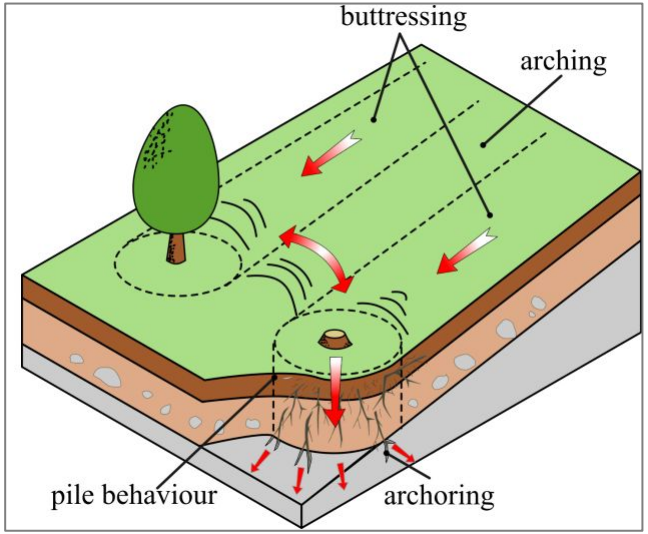
Dumitru, A. & Wendling, L. (2021)

Effect of vegetation on slope stability

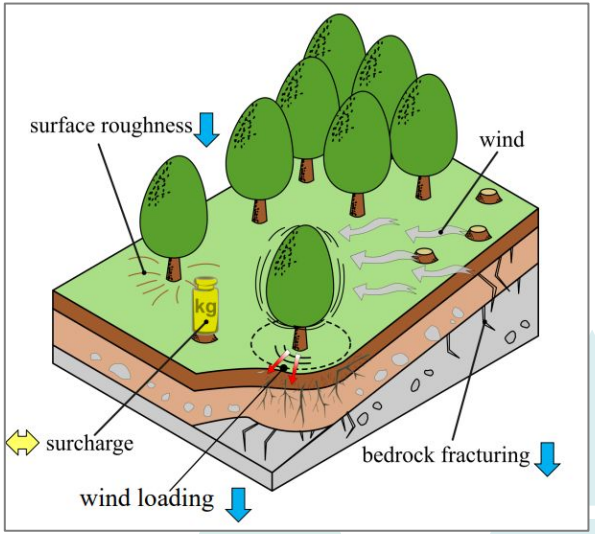
Improving
Neutral
Reducing



Hydrological effects



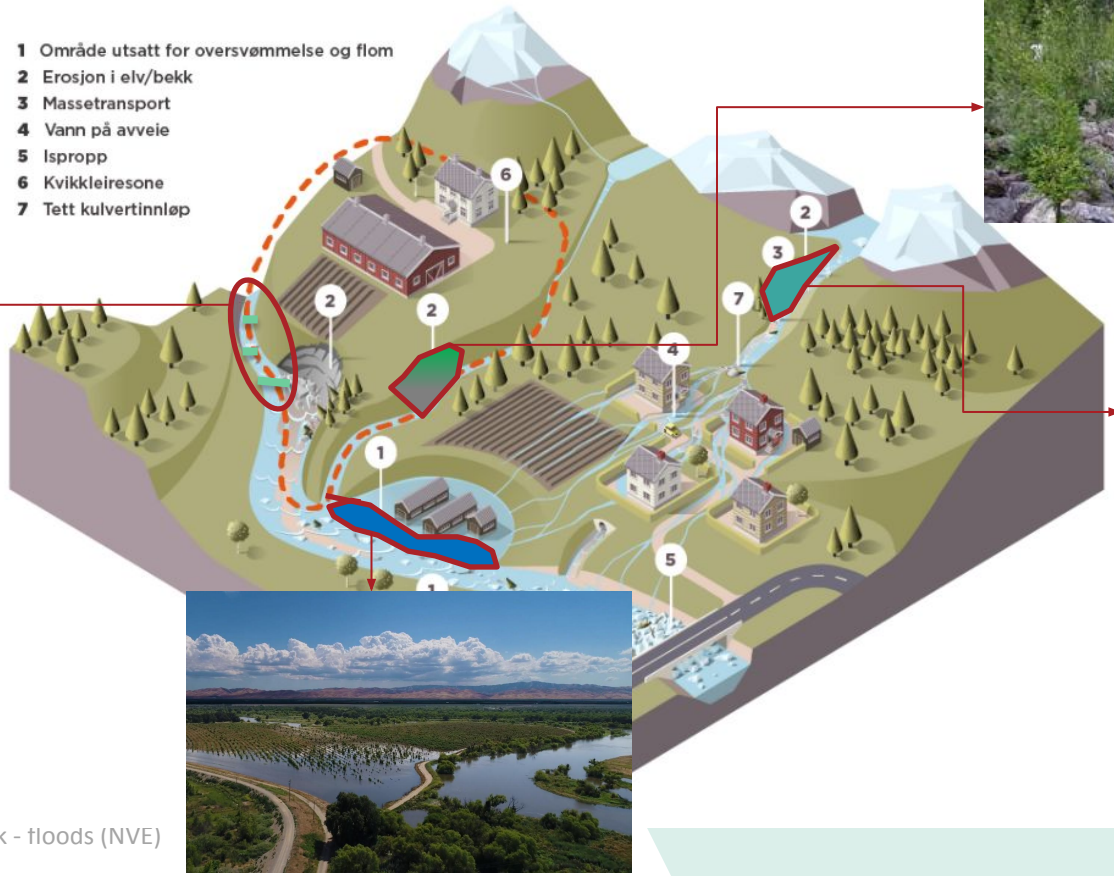
Mechanical effects



Other effects

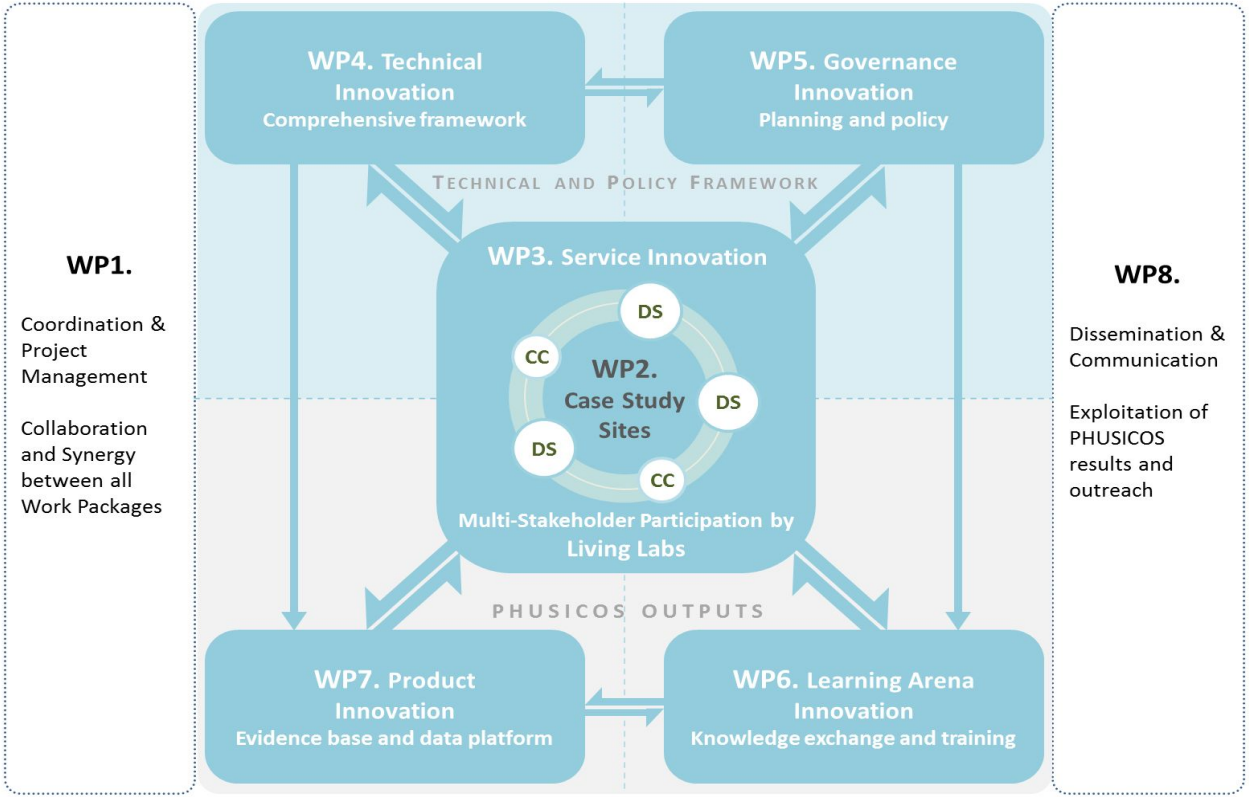
(Cislaghi, 2018)

Potential NBS for flooding and erosion



PHUSICOS – project organisation

- 8 Work Packages centered around case studies
- 15 partners from 7 countries
- Duration: 5 years (2018-2023)
- Budget: 10 mill. €



Case study sites and NBS implementations

Site	Hazard (NBS Intervention)
Gudbrandsdalen, Norway	Flooding (Receded green barrier – not to be implemented) Flooding (Retention high in catchment) Flooding, debris flow (Vegetation, check dam) Flooding, torrents (Historic water ways suggested by local stakeholders)
Isar River Basin, Germany	Flooding (Flood plain restoration already implemented)
Kaunertal, Austria	Erosion, landslides (microbe-assisted revegetation)
Serchio River Basin, Italy	Erosion, run-off, pollution, flooding (Vegetated buffer strips at two locations and education) Flooding (Vegetated retention basin) Flooding (Gentle channel maintenance)
Pyrénées, France & Spain	Erosion, rockfall (Vegetated terraces) Rockfall (Wood structures) Snow avalanche (Afforestation) Debris flow (Wooden gabions with vegetation)

Demonstrator cases and related risks

EROSION

Santa Elena

Artouste

ROCKFALL

Serchio

Jorekstad

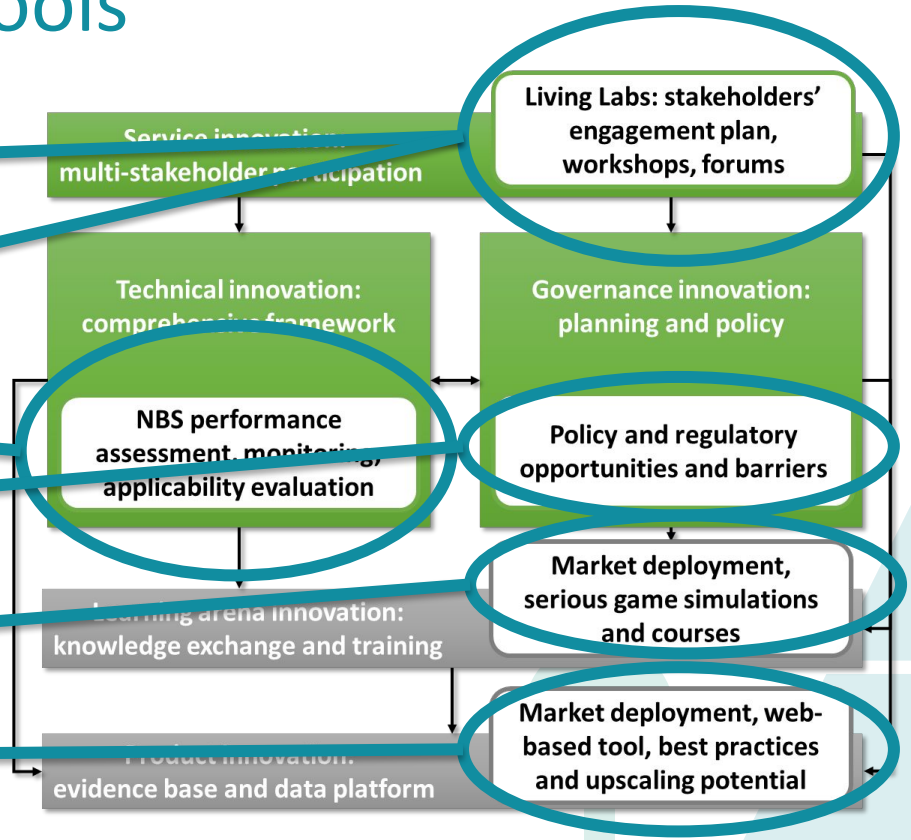
FLOODING

Barèges

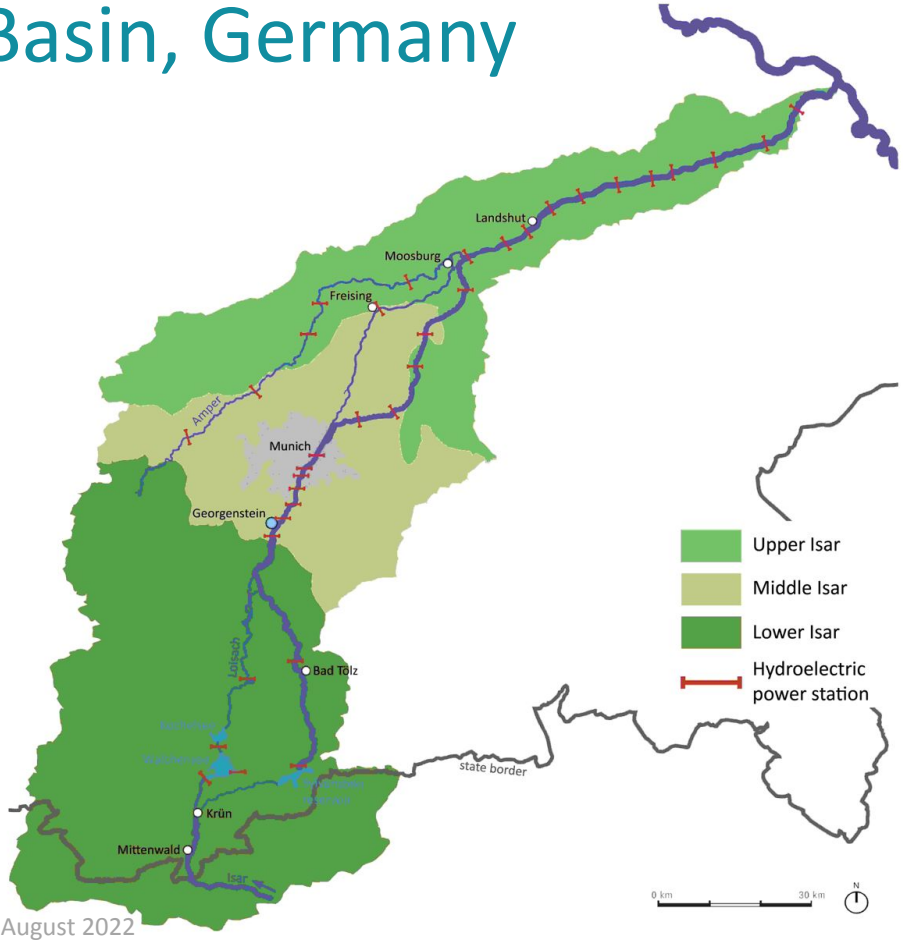
SNOW AVALANCHE

PHUSICOS Innovation tools

- Living Labs Guiding Framework (D3.1)
- Stakeholder Knowledge Mapping Starter Toolbox (D3.2)
- Framework for NBS Assessment (D4.1)
- NBS Successful Governance Models (D5.1)
- NBS VR and serious game simulation (D6.1 and D6.3)
- Web-based Inventory of NBS (D7.1 and D7.2)



Isar River Basin, Germany



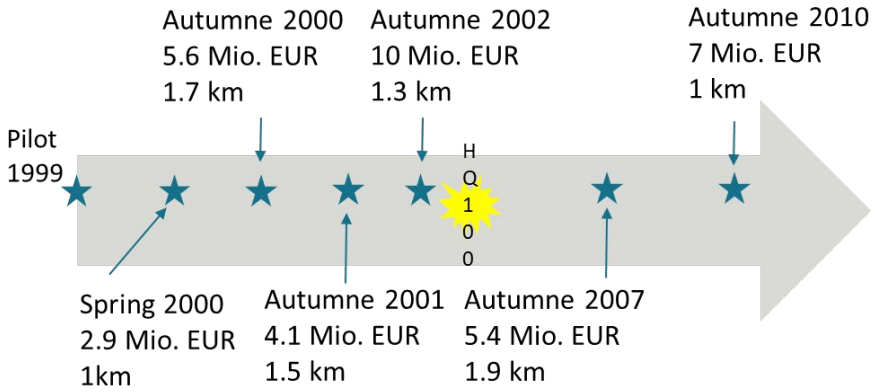
Isar River, Germany – the ‘Isar-Plan’

- 8 kilometers
- Bank flattening
- Increased flooded area
- Bed expansion and river braidening
- Removal of artificial embankment
- Honey comb structure
- Secondary Dam rehabilitation

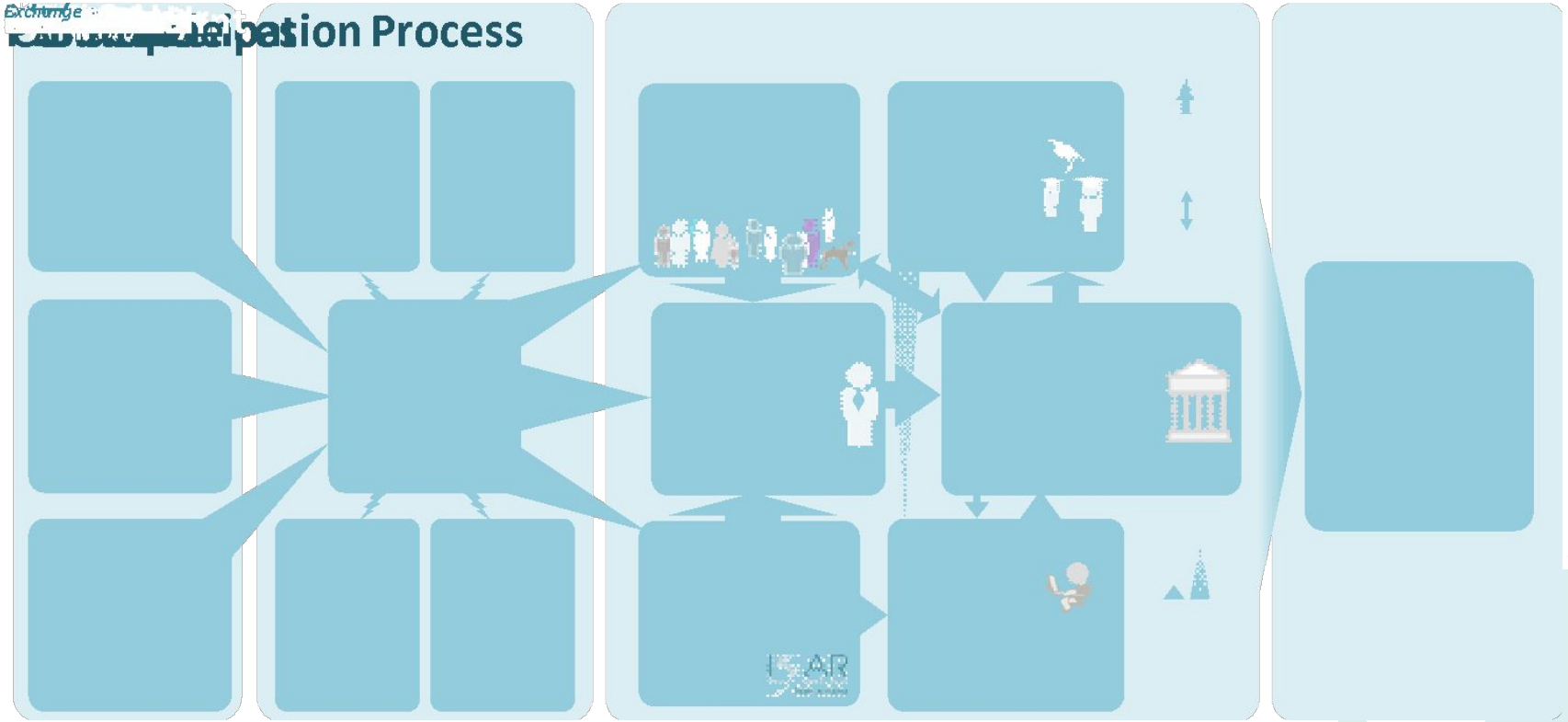
Implemented Isar-Plan (Aude Zingraff-Hamed, May 2015)

Isar River, Germany – the ‘Isar-Plan’

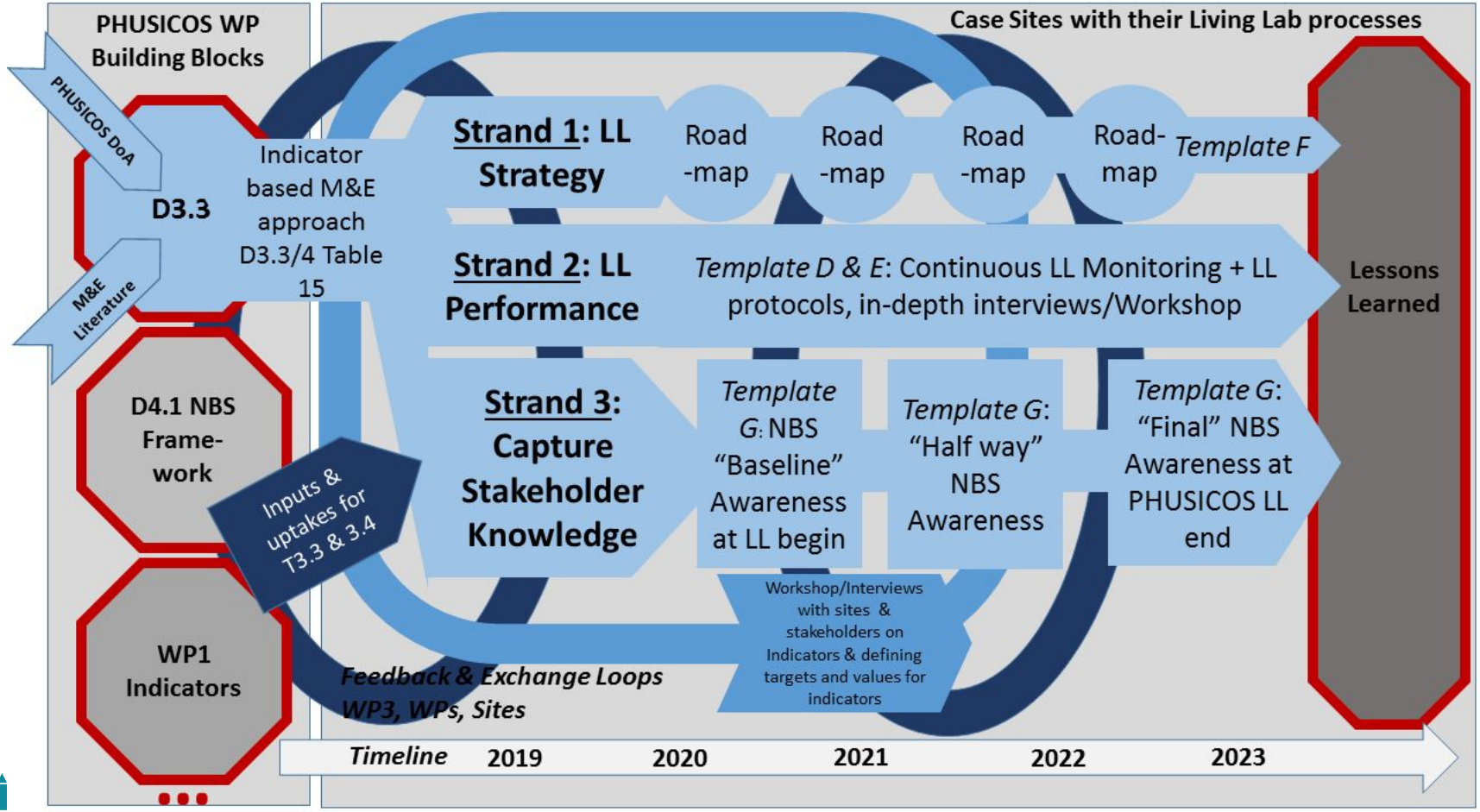
- Funding:
  - 35,000,000 Euros
  - Funded by: City government & Water agency
- Flood risk reduction:
  - Avoid goods destruction and life loss (HQ100)
  - Hydro-morphological simulation
  - 3D flow Model
- Co-benefits:
  - Good Ecological Status
  - Increase of recreational uses (conflict with ecological benefits)
  - Increase of cultural value
  - More restaurants
  - Increased tourism
  - Increase of the housing value



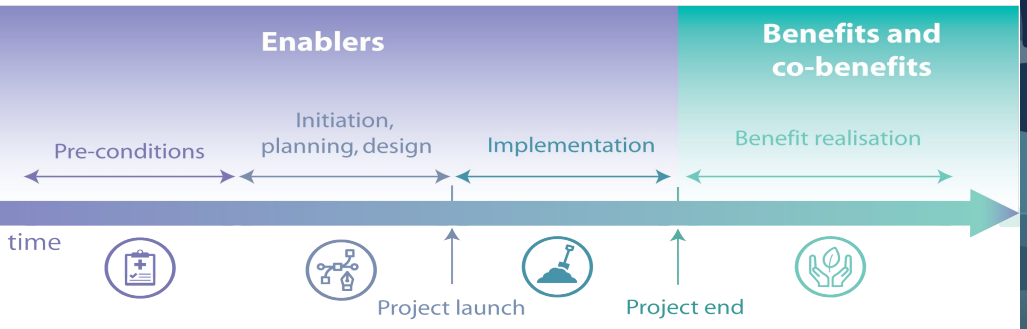
Isar River, Germany – the ‘Isar-Plan’

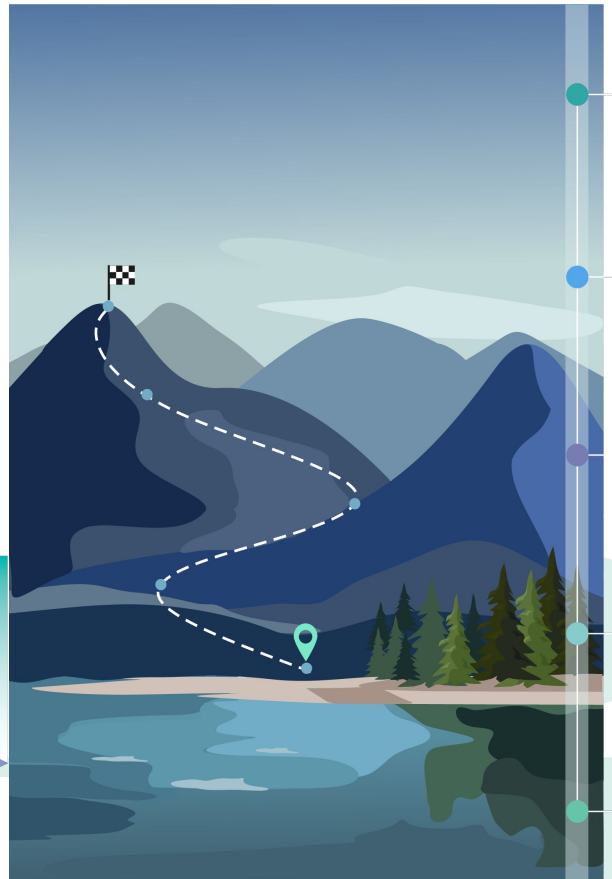


Composition of the Isar Living Lab and relations between its key components. Design: Christian Smida (PHUSICOS D3.1 pp 38)


PHUSICOS WP Building Blocks
PHUSICOS DoA
D3.3
M&E Literature
Indicator based M&E approach D3.3/4 Table 15
D4.1 NBS Frame-work
WP1 Indicators
Inputs & uptakes for T3.3 & 3.4
Case Sites with their Living Lab processes
Strand 1: LL Strategy
Road -map
Road -map
Road -map
Road-map
Template F
Strand 2: LL Performance
Template D & E: Continuous LL Monitoring + LL protocols, in-depth interviews/Workshop
Lessons Learned
Strand 3: Capture Stakeholder Knowledge
Template G: NBS "Baseline" Awareness at LL begin
Template G: "Half way" NBS Awareness
Template G: "Final" NBS Awareness at PHUSICOS LL end
Workshop/Interviews with sites & stakeholders on Indicators & defining targets and values for indicators
Feedback & Exchange Loops WP3, WPs, Sites
Timeline
2019
2020
2021
2022
2023

Enablers - review of selected case studies





01 POLITICAL WILL AND SUPPORT

02 POLYCENTRIC ARRANGEMENTS

03 STAKEHOLDER ENGAGEMENT AND CO-DESIGN

04 COALITION AND ADVOCACY GROUPS

05 AWARENESS RAISED THROUGH EVENT

PHUSICOS

The PHUSICOS NBS Simulation

WEBINAR

Centre for Systems Solutions

IIASA

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 776681

Learning arena innovation: NBS Simulation

- Moderator's Handbook:
  - Explanation of different elements of simulation and its flow
  - Tips for organizing simulation workshop
- Webinar online:
  - https://www.youtube.com/watch?v=Y1R35YfM1GM

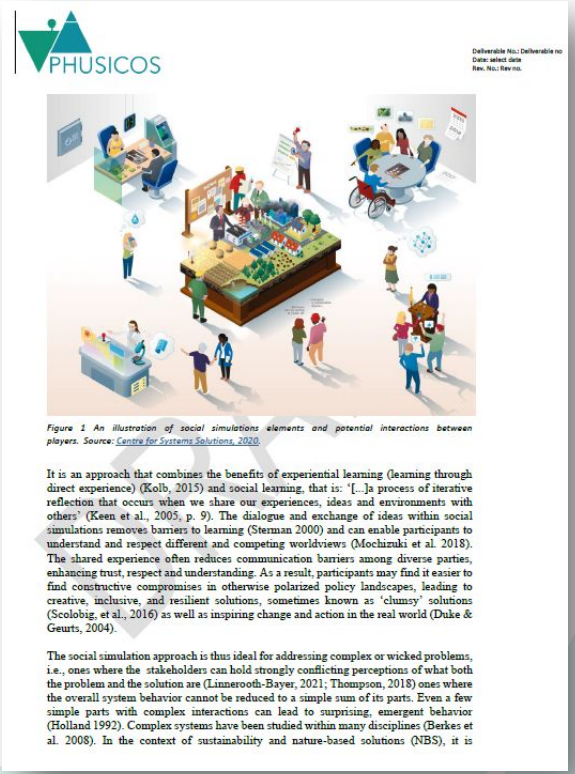


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Figure 1 An illustration of social simulations elements and potential interactions between players. Source: Centre for Systems Solutions, 2020.

It is an approach that combines the benefits of experiential learning (learning through direct experience) (Kolb, 2015) and social learning, that is: '[...]a process of iterative reflection that occurs when we share our experiences, ideas and environments with others' (Keen et al., 2005, p. 9). The dialogue and exchange of ideas within social simulations removes barriers to learning (Sterman 2000) and can enable participants to understand and respect different and competing worldviews (Mochizuki et al. 2018). The shared experience often reduces communication barriers among diverse parties, enhancing trust, respect and understanding. As a result, participants may find it easier to find constructive compromises in otherwise polarized policy landscapes, leading to creative, inclusive, and resilient solutions, sometimes known as 'clumsy' solutions (Scolobig, et al., 2016) as well as inspiring change and action in the real world (Duke & Geurts, 2004).

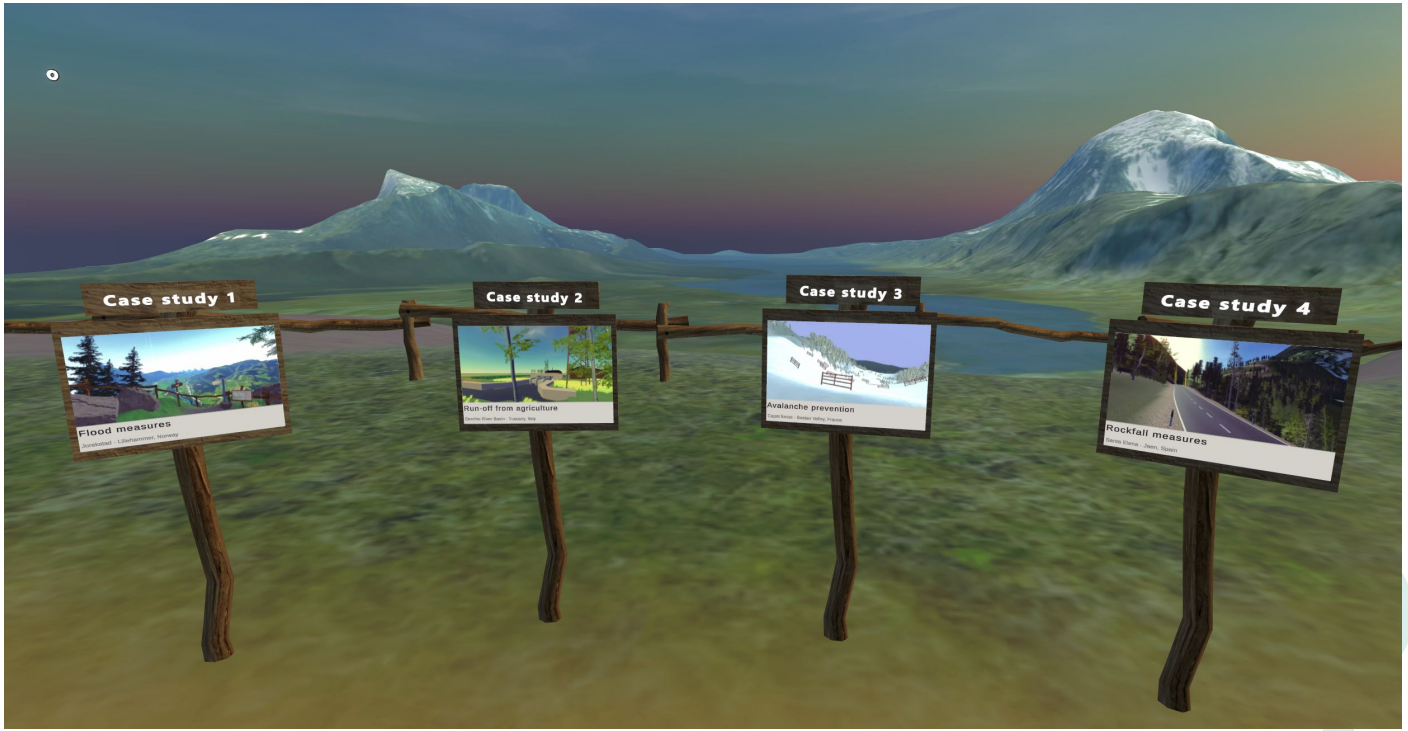
The social simulation approach is thus ideal for addressing complex or wicked problems, i.e., ones where the stakeholders can hold strongly conflicting perceptions of what both the problem and the solution are (Linnerooth-Bayer, 2021; Thompson, 2018) ones where the overall system behavior cannot be reduced to a simple sum of its parts. Even a few simple parts with complex interactions can lead to surprising, emergent behavior (Holland 1992). Complex systems have been studied within many disciplines (Berkes et al. 2008). In the context of sustainability and nature-based solutions (NBS), it is

Learning arena innovation: PHUSICOS VR
Virtual reality for real learning

- The original plan was to produce a webinar or video
- VR offers significant improvements
  - Broader reach and more playful and exciting than a webinar
  - Longer shelf life, new content can easily be added
  - Higher pedagogical impact as VR engages the user and enhances understanding of complex topics

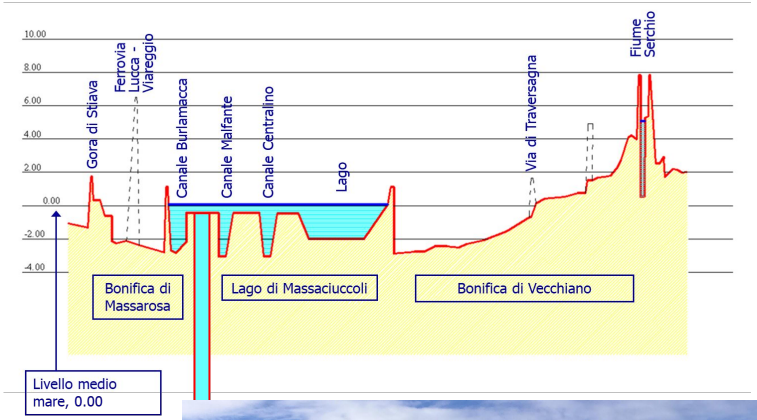
Four case study sites showcased

modular software design so that others can easily be added



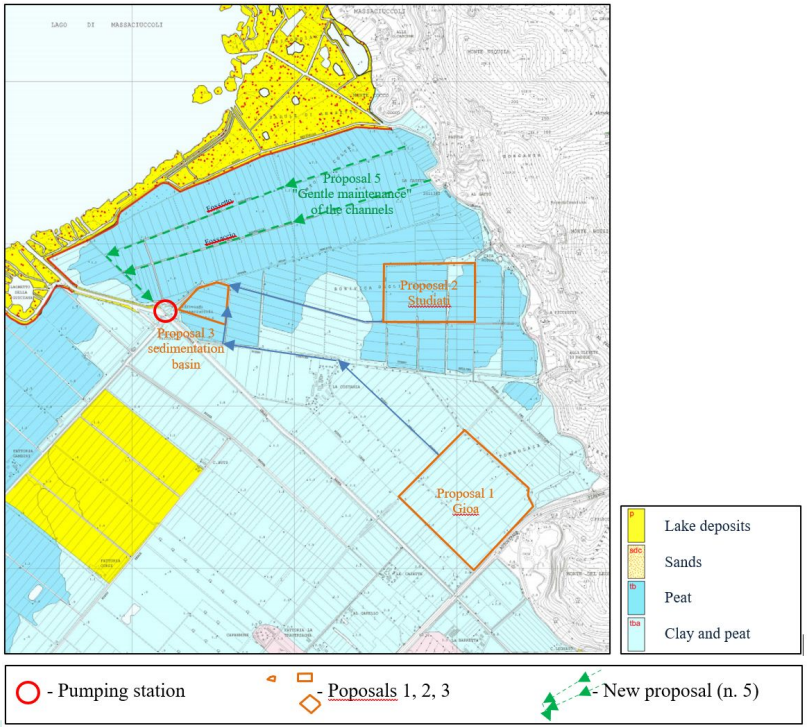
PHUSICOS-VR: Virtual reality for real learning - YouTube

Serchio River / Lake Massaciuccoli, Italy



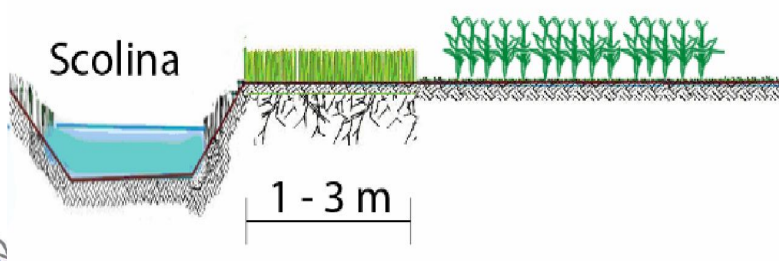
Serchio River / Lake Massaciuccoli, Italy

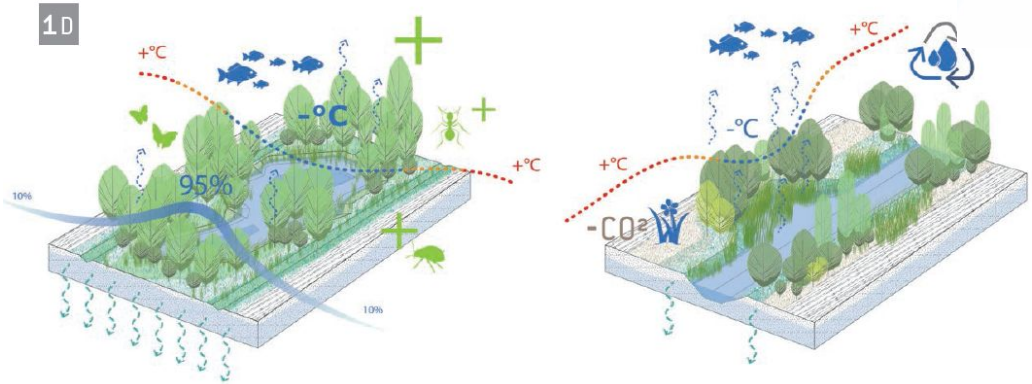
- Buffer strips (proposal 1/A & 2/B)
- Sedimentation basin (proposal 3/C)
- NBS Living Lab (proposal 4/D) - educational purpose, combined classroom and field activities
- Gentle channel maintenance (proposal 5)



Lake Massaciuccoli buffer strips

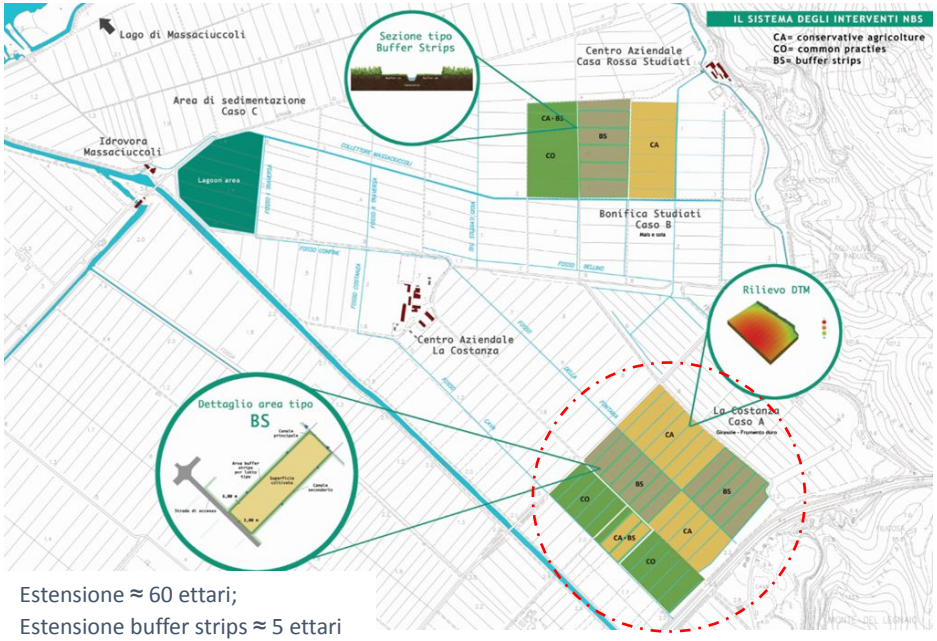
- Vegetation to reduce runoff from fields, to canals and the lake
- Natural water pockets within the engineered network





Intervention 1 (Gioia Farm) – Implemented

Buffers strips and conservative agriculture



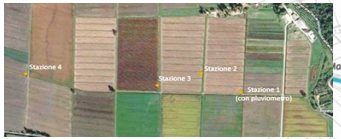
Estensione ≈ 60 ettari;
Estensione buffer strips ≈ 5 ettari

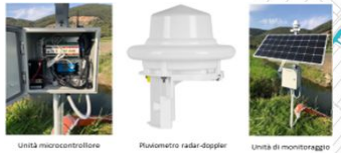
Buffers strips/conservative agriculture aim to:

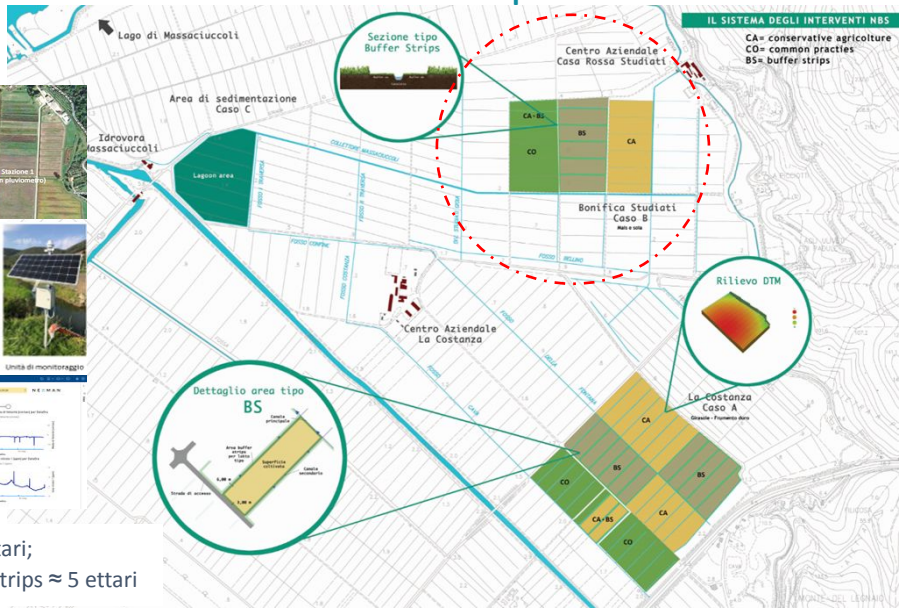
- limit soil erosion and transport in canals;
- limit the pollutants transfer from soils to hydraulic net;
- promote a process of improving water quality;
- increase the resilience of the territory;

Intervention 2 (Studiati Farm) – Implemented

Buffers strips and conservative agriculture







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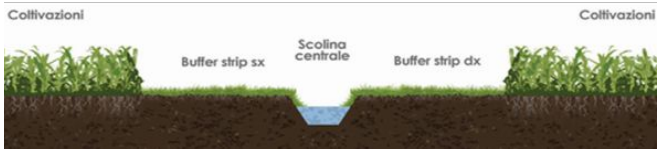

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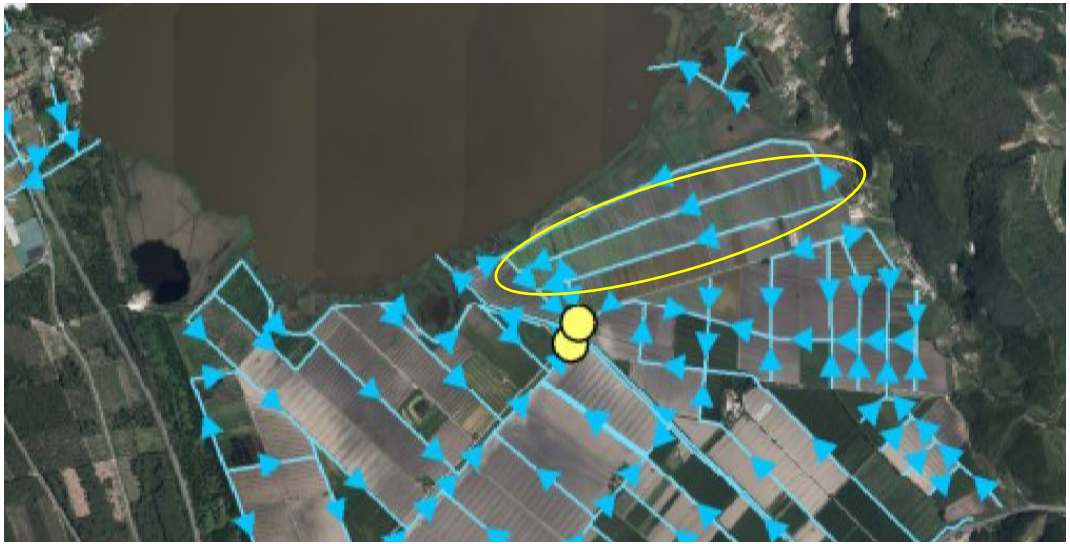
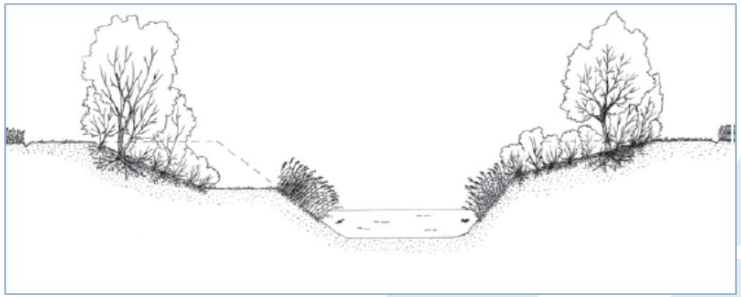
Lake Massaciuccoli gentle channel maintenance





- Revision of hydraulic net
- Increase of the hydraulic sections
- Planting of riparian vegetation
- Creation of wetlands

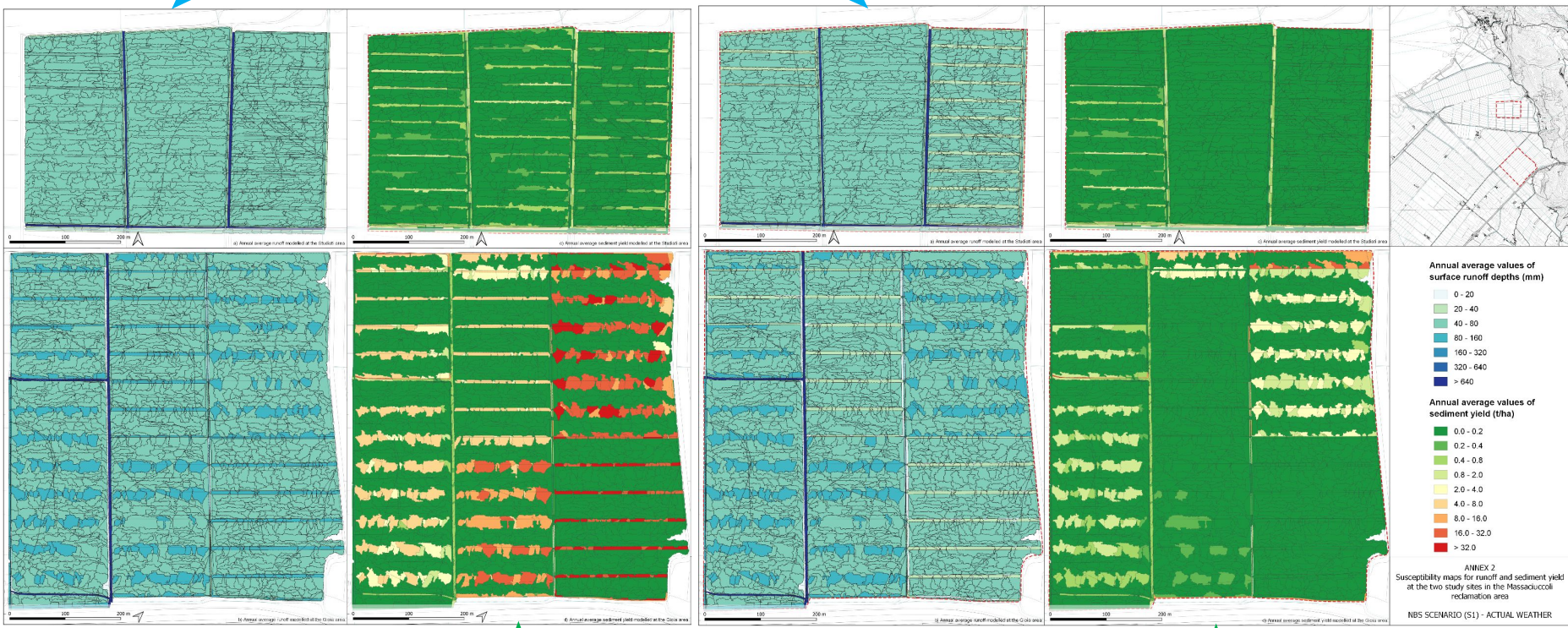
Lake Massaciuccoli gentle channel maintenance

Baseline scenario

NBS scenario

AVERAGE ANNUAL SURFACE RUNOFF DEPTHS (mm H2O)

Actual Climate



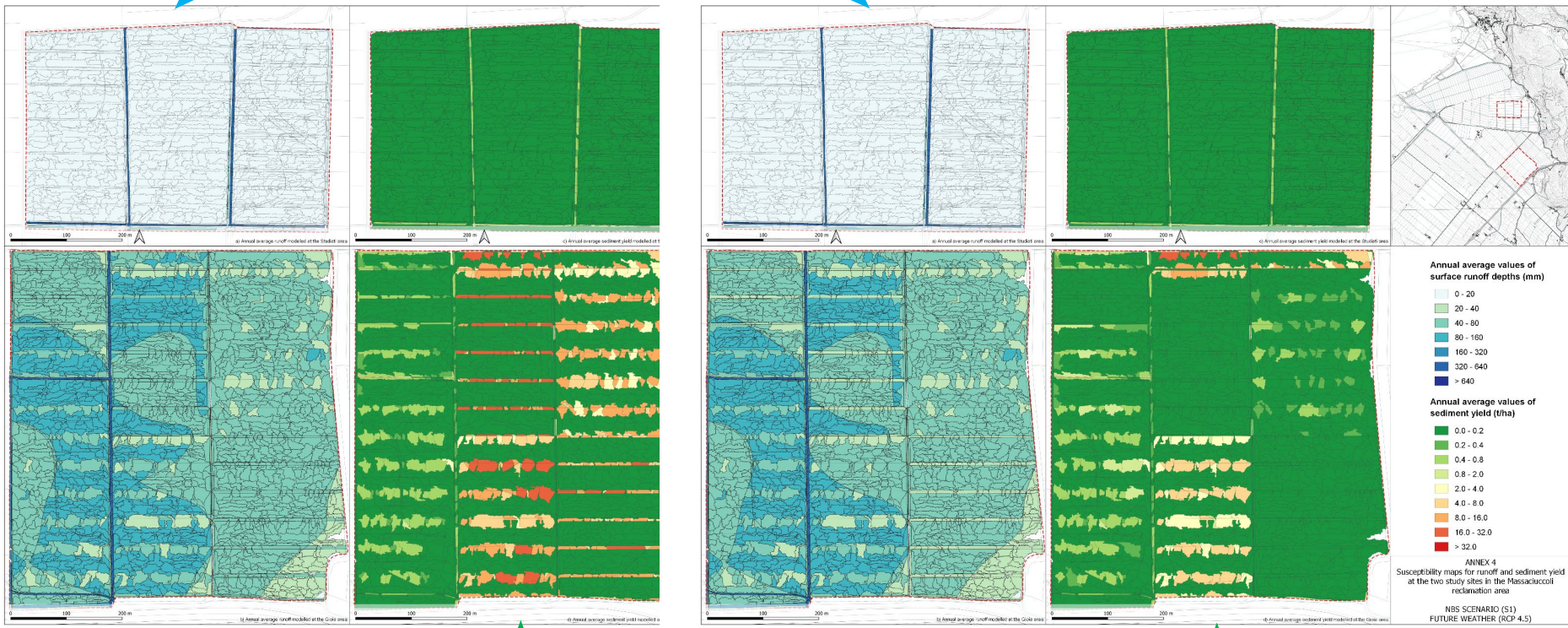
AVERAGE ANNUAL SEDIMENT YELD (t/ha)

Baseline scenario

NBS scenario

AVERAGE ANNUAL SURFACE RUNOFF DEPTHS (mm H2O)

Future Climate (RCP 4.5)



AVERAGE ANNUAL SEDIMENT YELD (t/ha)

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Thank you!

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