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Nature-based Solutions for hydro-meteorological hazards

Assessing risks in Socio-Ecological Systems

Fabrice Renaud and Paolo Ruggieri

EU funded project
GA no. 776848

Outline – Part 1

- Introduction and Definitions
- Examples of NbS to reduce risks
- Capturing the role of NbS to reduce risks: Understanding the system through impact chains
- Capturing the role of NbS to reduce risks: Indicator-based risk assessment

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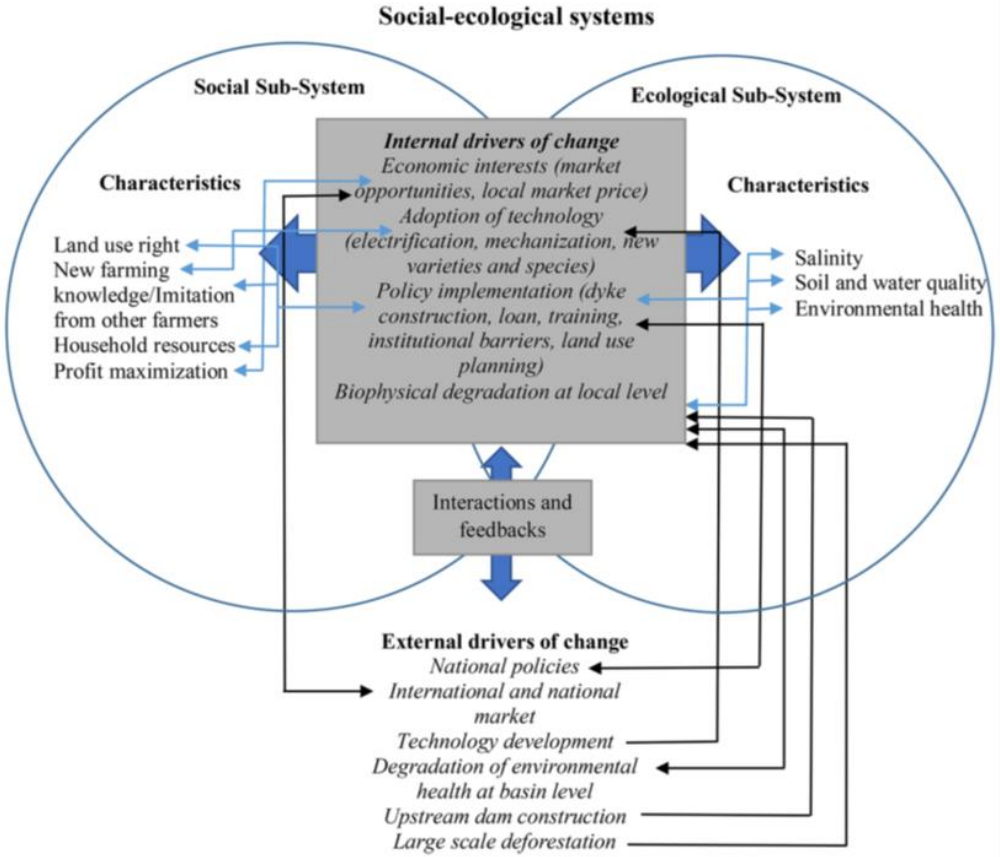
Introduction and Definitions

Social-Ecological Systems

Social-ecological Systems:
Complex systems of people and nature, emphasizing that humans must be seen as a part of, not apart from, nature

Source: Adapted from Berkes and Folke (1998): Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge, UK: Cambridge Univ. Press.



Source: Minh Tu Nguyen, Renaud & Sebesvari (2019): Environmental Science and Policy 92 (2019) 331–348. Permission granted via RightsLink® service

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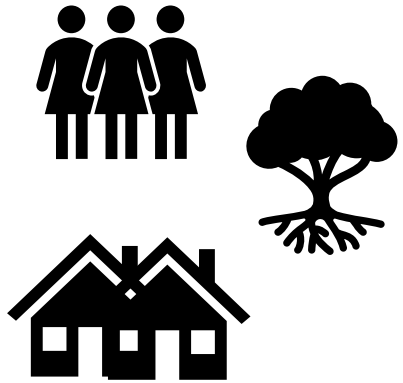
Risk and Vulnerability

Risk = f (Hazard , Exposure , Vulnerability)

Characteristics of:
Natural hazards (for example: drought, flood, storm surge, landslide).
and / or Technological hazards

People, ecosystems, infrastructure



Susceptibility, coping capacity, adaptive capacity, ecosystem robustness

Social, Economic, Environmental, Institutional

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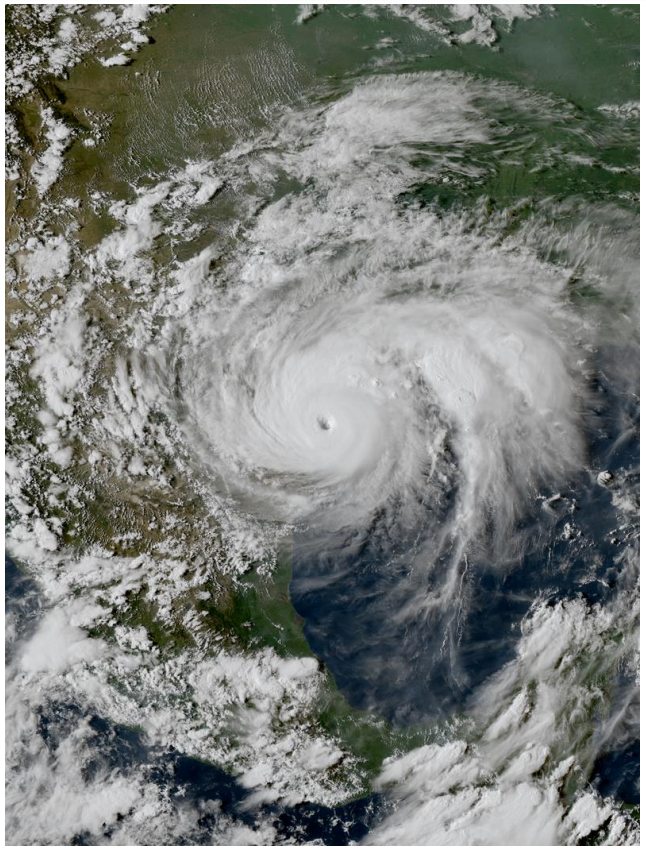
Some natural hazards



Satellite image of Hurricane

Source: NOAA GOES-16 satellite
Harvey 2017-08-25 2231Z.png
Public Domain

Storm surge breaching coastal defences

Source: Image by Jerry Coli from Pixabay
Free for commercial use

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Some natural hazards

Flooded city

Source: Commander Mark Moran et al.
Katrina-new-orleans-flooding3-2005.jpg
Public Domain

Dust bowl (drought)

Source: Sloan/USDA
Dust Bowl - Dallas, South Dakota 1936.jpg
Public Domain

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Exposure - Definition

Exposure:

The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC 2014a, p. 39)

Houses exposed on the coastline

Source: Fabrice Renaud/UNU-EHS

Sources for the definitions are to be found in Hagenlocher et al (2018): Climate Risk Assessment for Ecosystem-based Adaptation: A guidebook for planners and practitioners. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn

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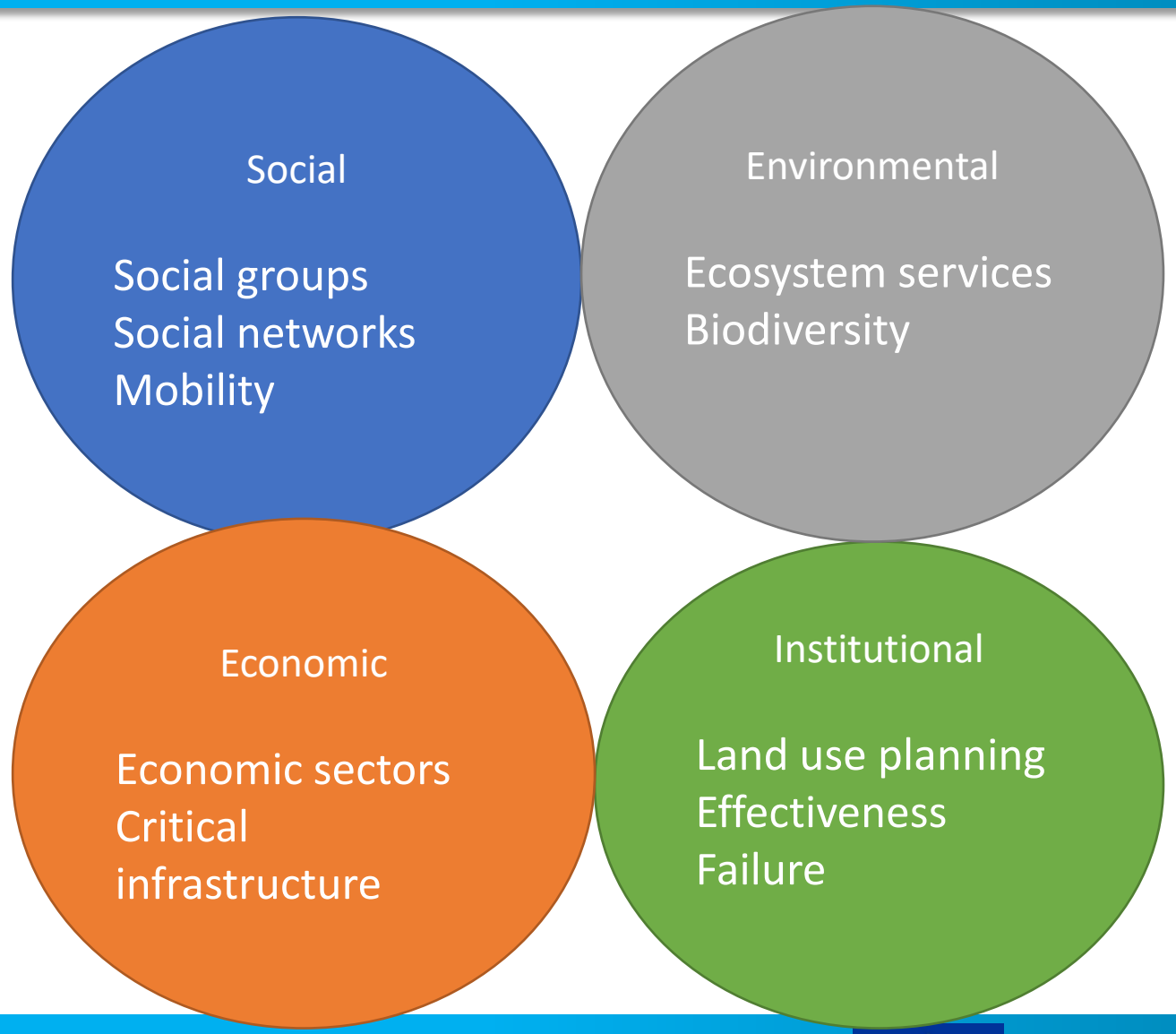
Vulnerability - Definition

Vulnerability:

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC 2014a, p. 39)

Sources for the definitions are to be found in Hagenlocher et al (2018): Climate Risk Assessment for Ecosystem-based Adaptation: A guidebook for planners and practitioners. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn



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Risk reduction – be careful with the “obvious”

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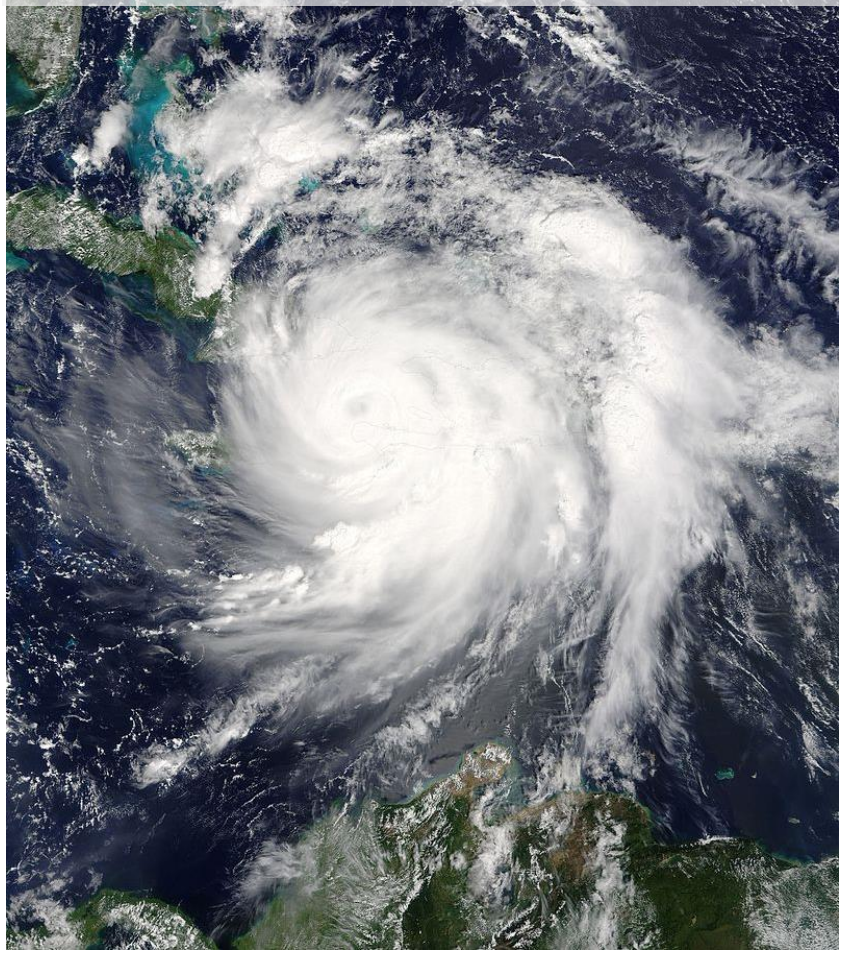
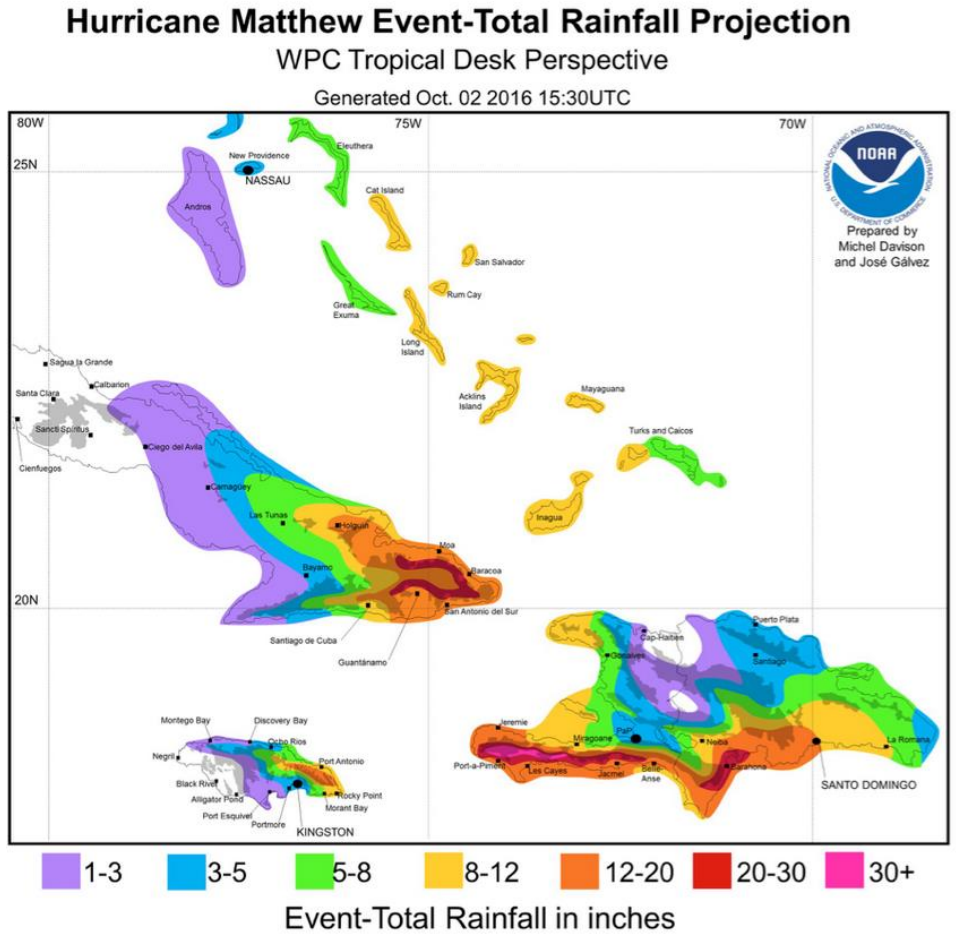
Hurricane Matthew near Haiti on October 4, 2016



Source: MODIS image captured by NASA’s Terra satellite - Rapid Response – LANCE
https://en.wikipedia.org/wiki/Effects_of_Hurricane_Matthew_in_Haiti#/media/File:Matthew_2016-10-04_1535Z.jpg



Source: https://www.theweathernetwork.com/us/news/articles/us-weather/hurricane-matthew-current-hazards-and-us-impact-florida-georgia-south-north-carolina-haiti-jamaica-cuba-dominican-republic-bahamas/72896/

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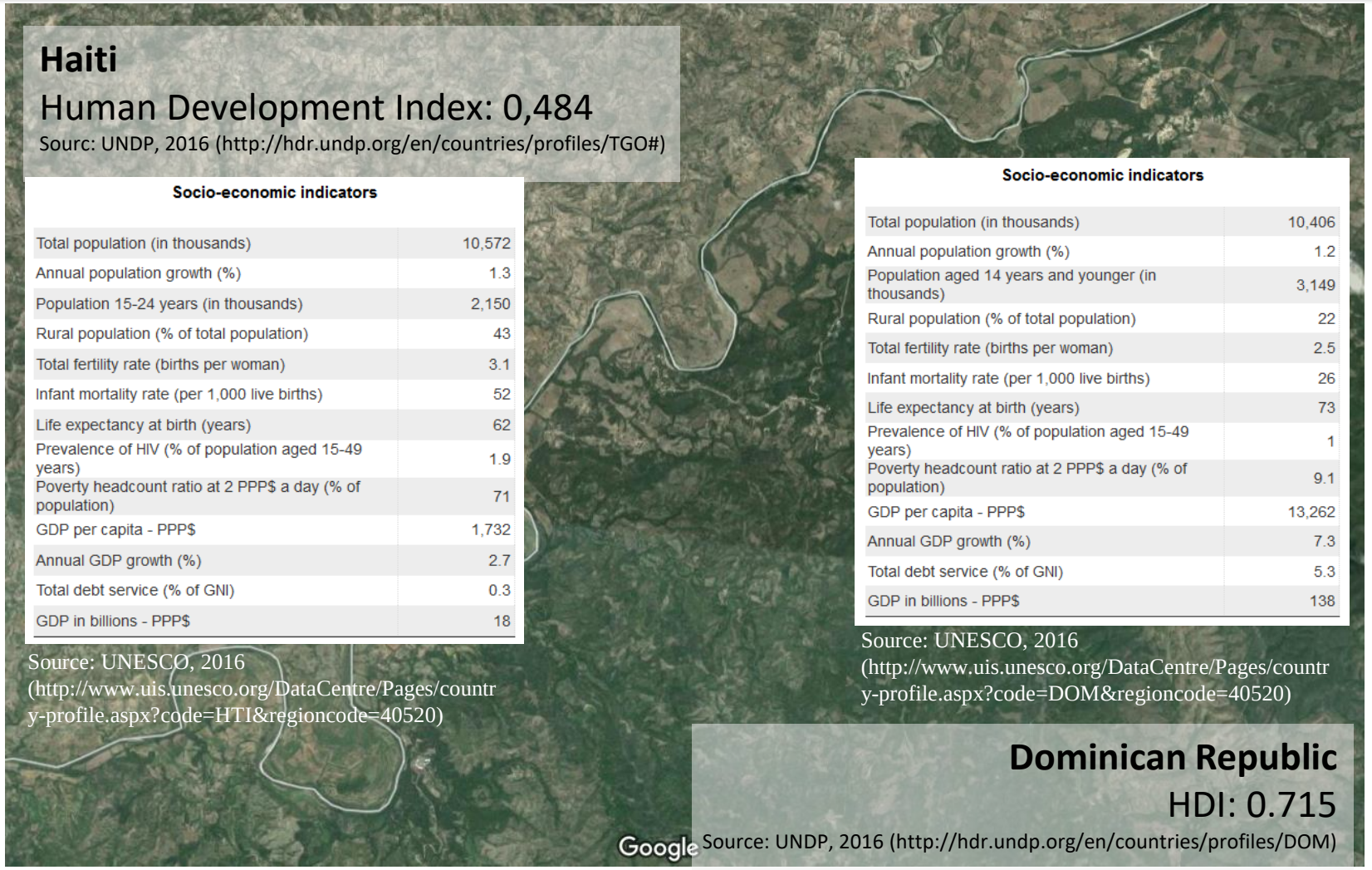
Risk reduction – be careful with the “obvious”



Approx 550 casualties in Haiti vs. < 10 in Dominican Republic

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Examples of NbS to reduce risks

Protecting ourselves from natural hazards

Sea-dyke, Mekong Delta, Vietnam

Mangrove, Mekong Delta, Vietnam

Mangrove and sea-dyke, Mekong Delta, Vietnam

Photo: Fabrice Renaud/University of Glasgow (2020)

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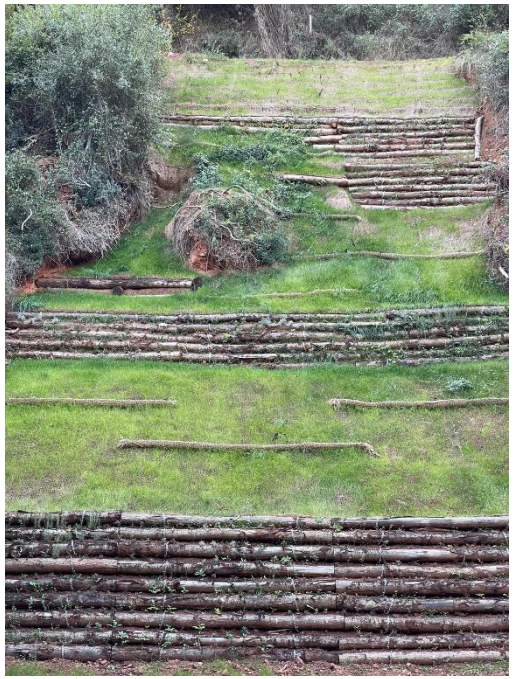
Beach of Roses Spain

Slope road restoration in Castellar del Vallès



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Works designed and executed by

Urban vegetation

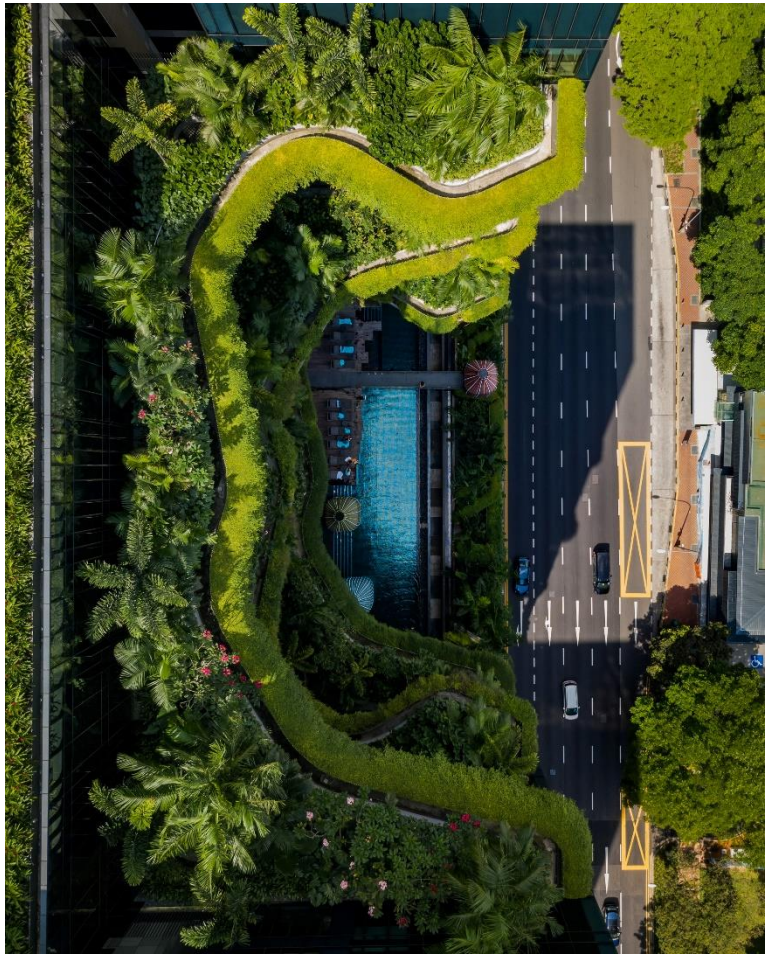

Photo by Nazarizal Mohammad on Unsplash
[re-use authorised]

Photo by Fabrice Renaud (2014)

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Transformation of urban parks

Bishan-Ang Mo Kio Park (2008 & 2011)

Source: By Pagodashophouse. - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=19065126

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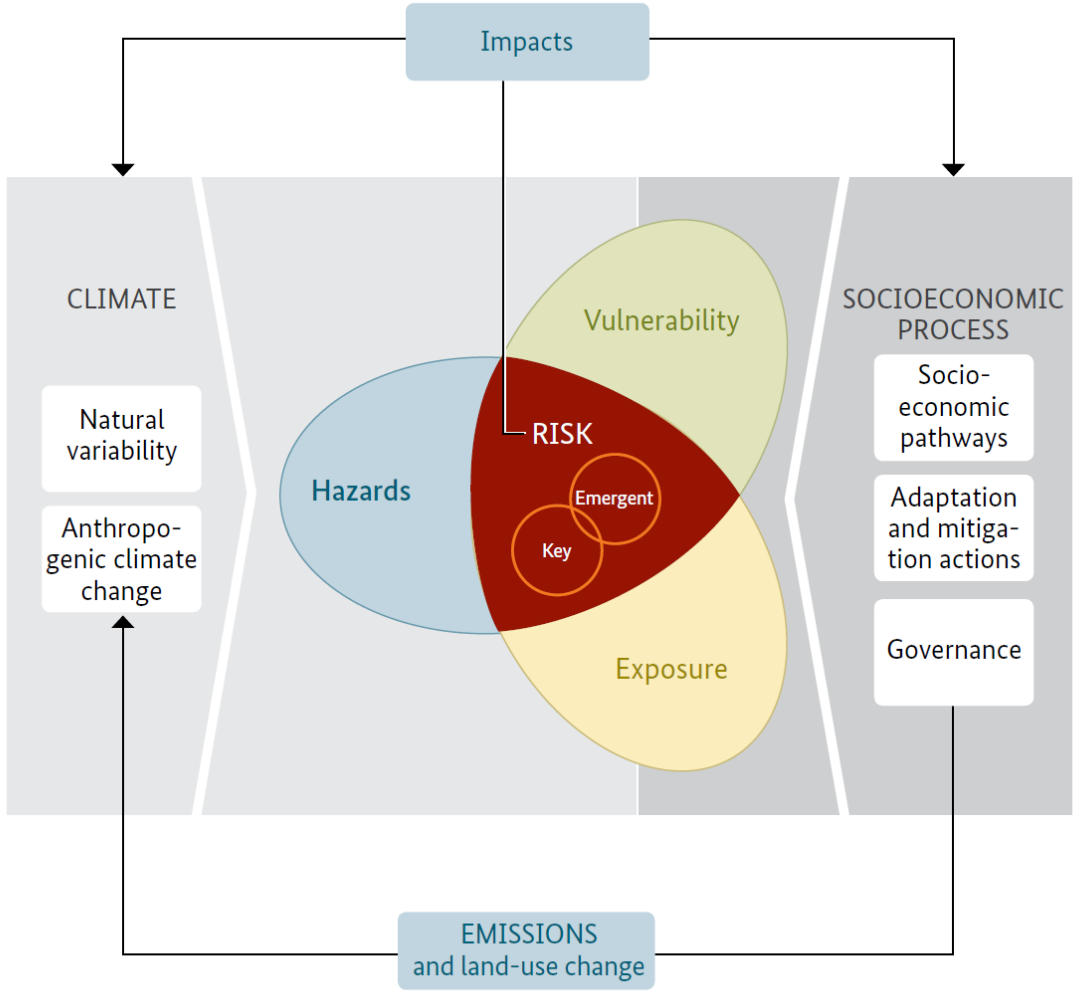
Capturing the role of NbS to reduce risks

Understanding the system through impact chains

Linking the concepts



Source: IPCC (2014) in Hagenlocher et al (2018): Climate Risk Assessment for Ecosystem-based Adaptation: A guidebook for planners and practitioners. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn

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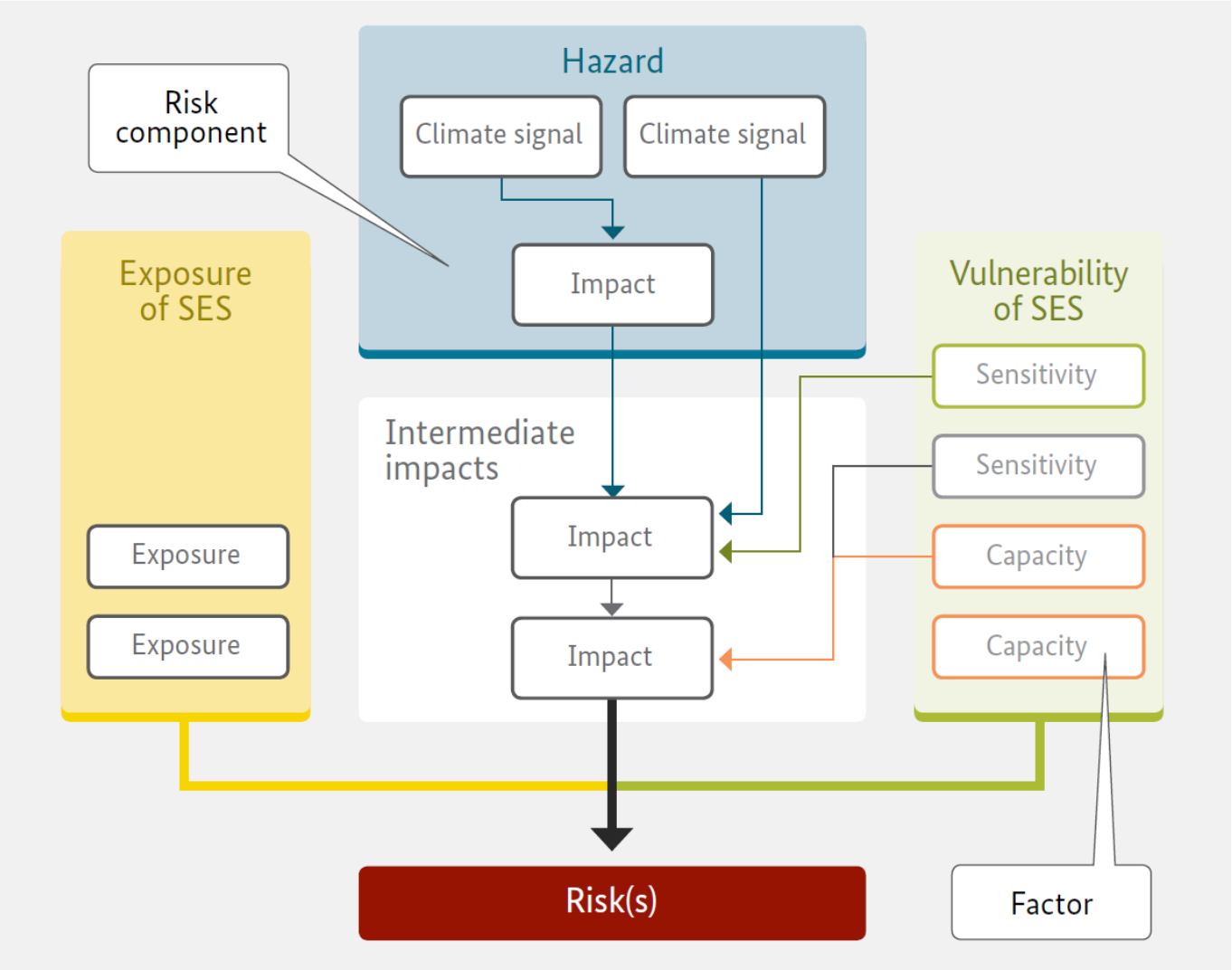
Example of chains in the risk assessment context



Hagenlocher et al (2018): Climate Risk Assessment for Ecosystem-based Adaptation: A guidebook for planners and practitioners. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Bonn

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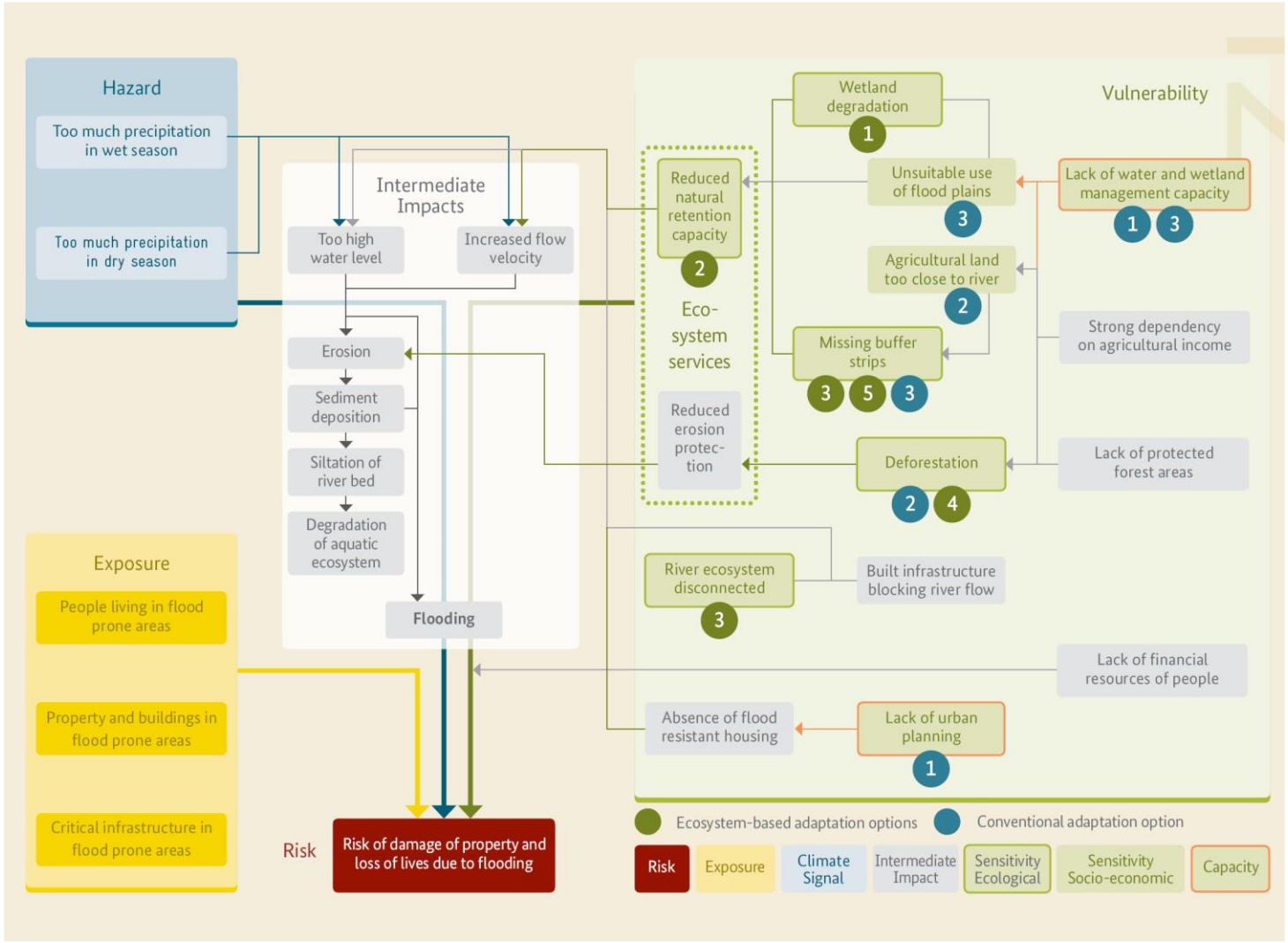
Example of an impact chain



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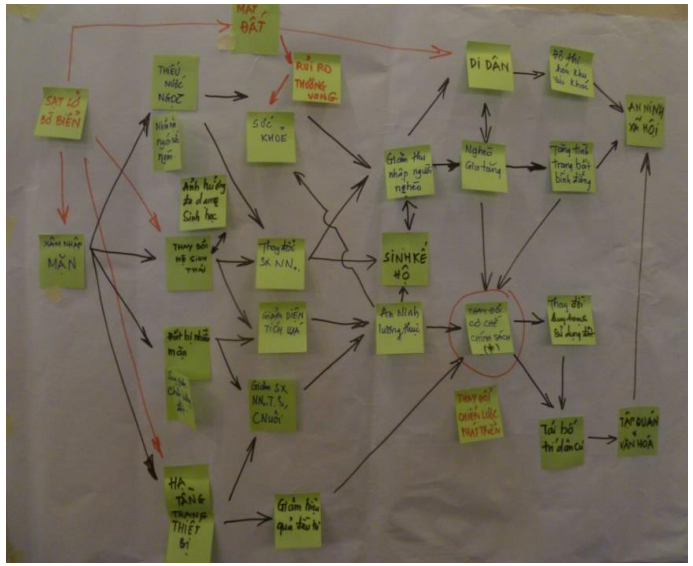
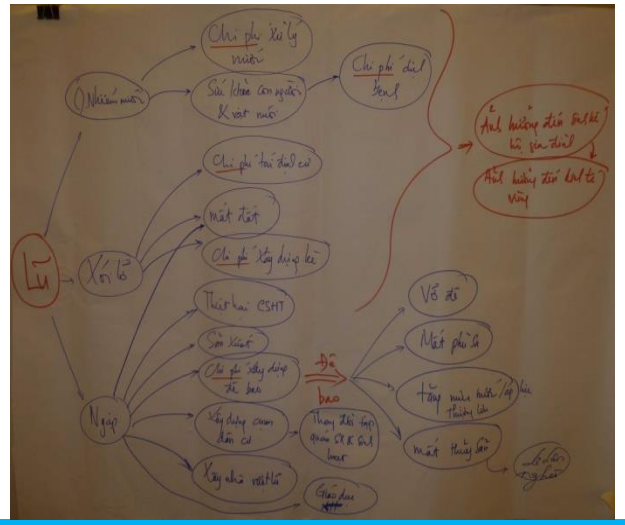
Used in research





Diagrams and postits used to develop impact chains

Source: Fabrice Renaud/UNU-EHS/University of Glasgow

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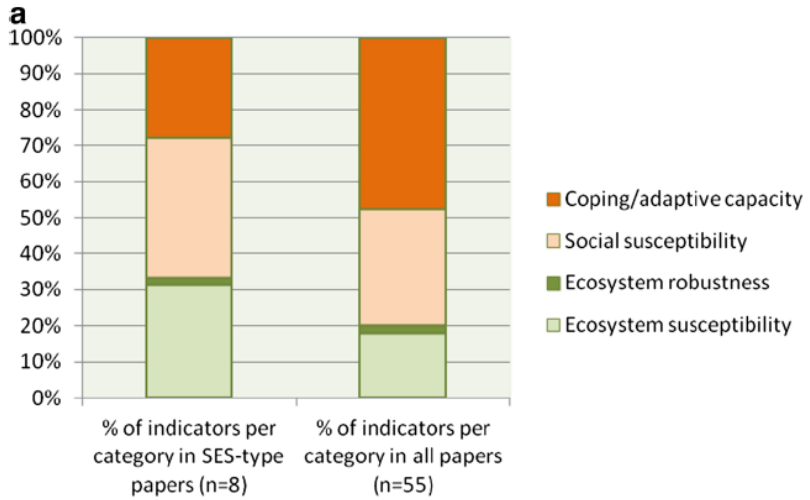
Capturing the role of NbS to reduce risks

Indicator-based risk assessment

The role of ecosystems is under-represented in risk assessments



Source: Sebesvari, Renaud et al. (2016). A review of vulnerability indicators for deltaic social–ecological systems. DOI 10.1007/s11625-016-0366-4

- Hagenlocher et al. (2019)
  - 9/62 Environmental dimension
  - 8/62 Farming practice dimension
- Shah et al. (2020)
  - 39% of reviewed indicators focus on ecological systems

Hagenlocher et al. (2019): *Environ. Res. Lett. 14:083002*
Shah et al. (2020): *International Journal of Disaster Risk Reduction 50:101728*

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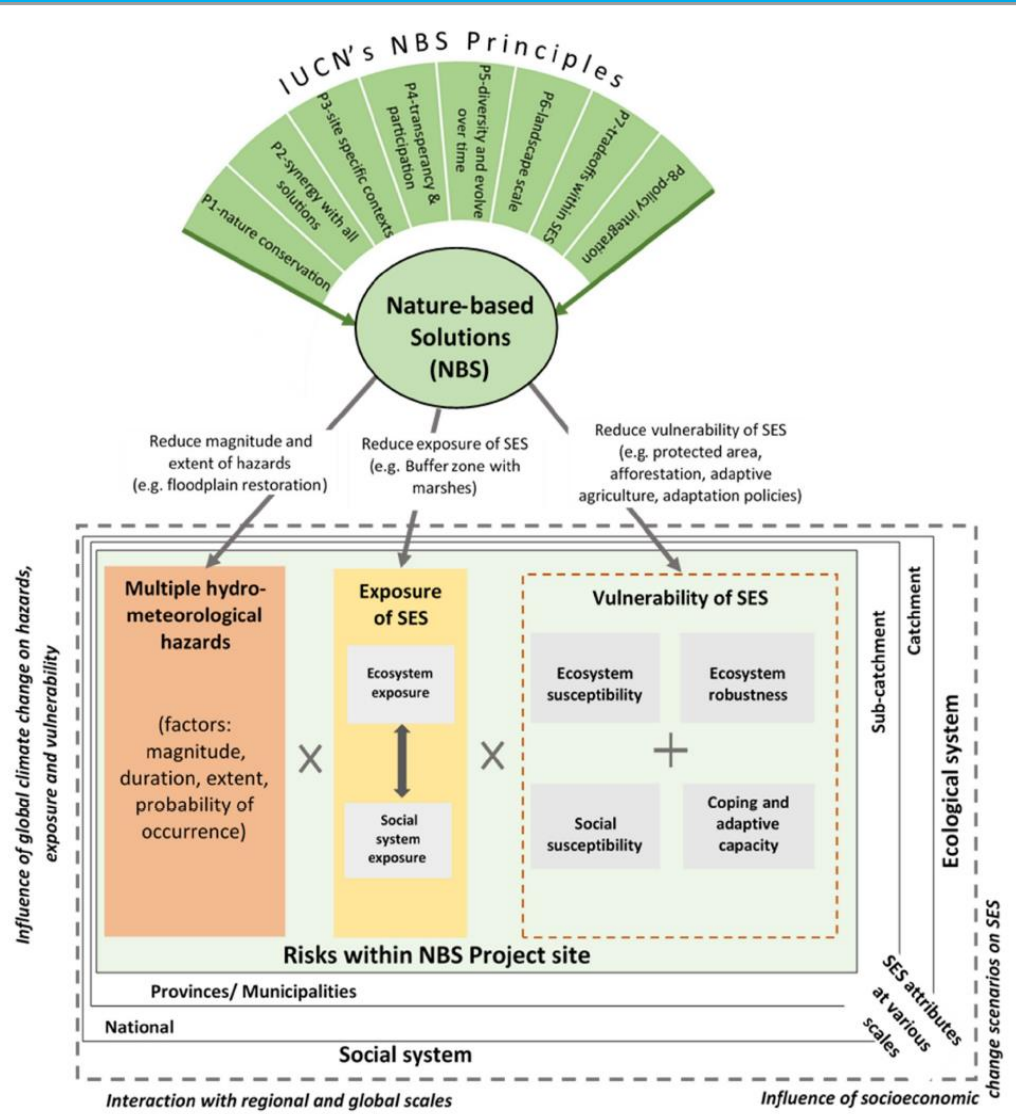
Conceptual framework for vulnerability and risk assessment of SES in the context of NbS



Source: Shah, Renaud et al. (2020). A review of hydro-meteorological hazard, vulnerability, and risk assessment frameworks and indicators in the context of nature-based solutions. *IJDRR, 50:101728*. [CC BY 4.0].

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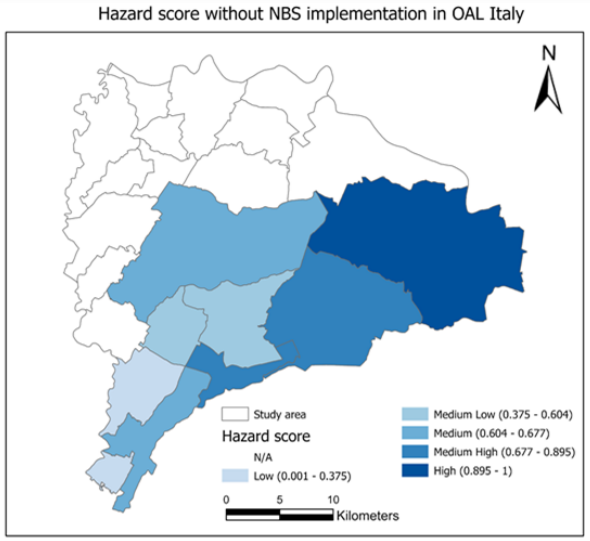
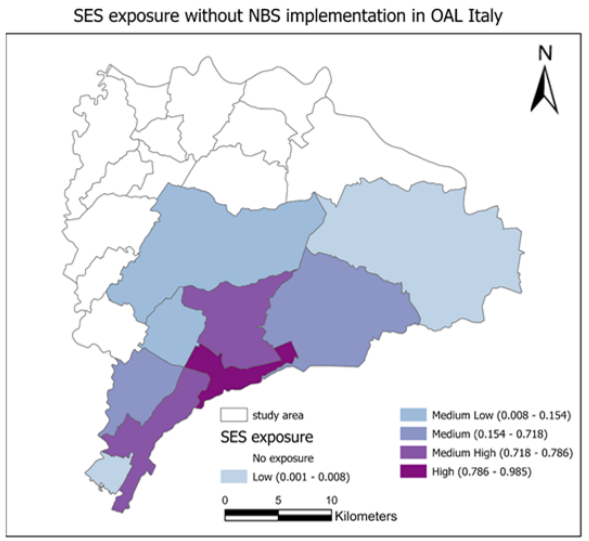
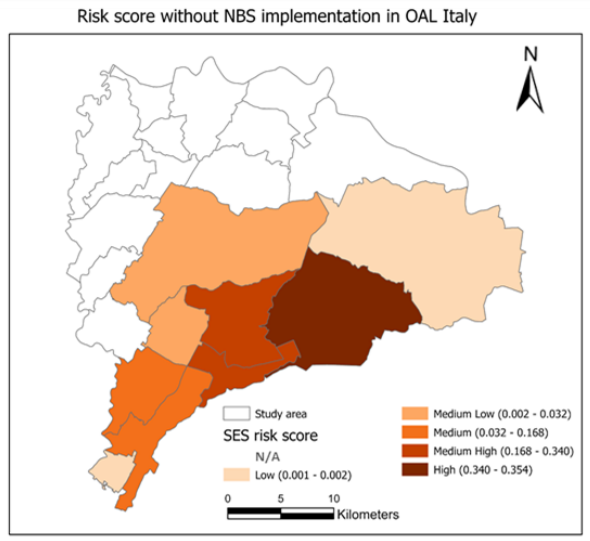
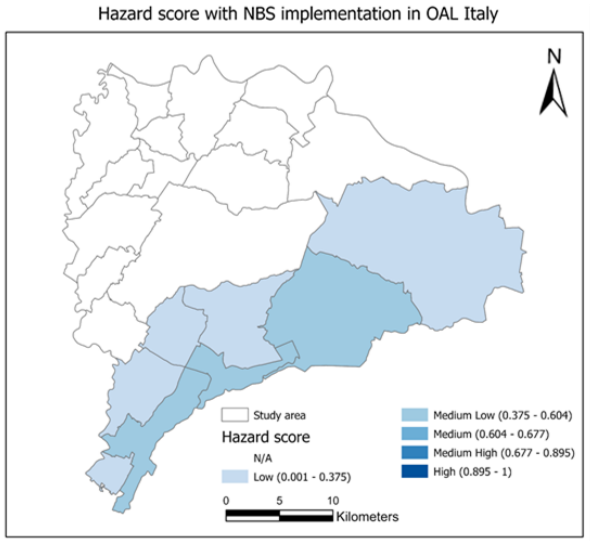
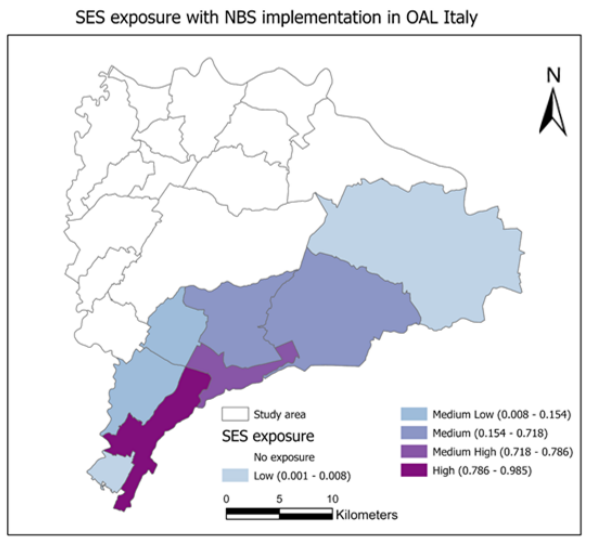
Example in the OAL-Italy Panaro using an indicator-based approach

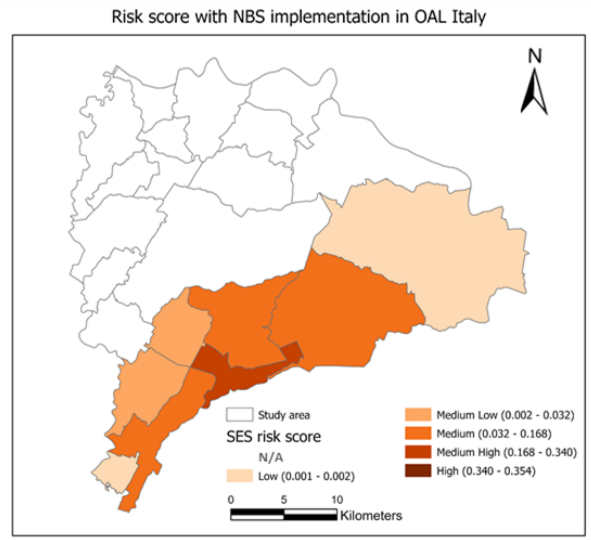












SES hazard, exposure, and risk scores for a 200-year flood event in OAL Italy for with and without NBS scenarios

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Data collection for different indicators

Primary data

Collected by the researcher through surveys, interviews, etc.

Examples:

- Number of income-generating activities per household
- Insurance coverage
- Dependency on road communication
- Participation in decision making
- Knowledge on climate / risks

Secondary data

Existing information in databases, publications, books, government websites, etc.

Examples:

- Land use
- Land exposed to hazards (e.g., flooding, landslide)
- Buildings
- Agricultural crop production
- Road and rail network
- NDVI (Normalized Difference Vegetation Index)
- Policies related to conservation, adaptations, etc.

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Calculation process for V&R assessment (1/2)

Data collection for V&R indicators

- Secondary sources
- Primary surveys

Normalization of indicator values (X_i')

- Min-max linear normalization

Combine normalized indicators for each vulnerability domain (VD)

- Ecosystem susceptibility
- Social susceptibility
- Lack of ecosystem robustness
- Lack of coping/adaptive capacities

$$VD = \sum_{i=1}^{n} (w_i * x_i')$$

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Calculation process for V&R assessment (2/2)

Calculate susceptibility **metric** (VD_{SUS})

$$VD_{SUS} = \sum_{j=1}^{n} (w_j * VD_j)$$

Calculate lack **of** capacities and robustness **metric** (VD_{CAR})

$$VD_{CAR} = \sum_{j=1}^{n} (w_j * VD_j)$$

Combined index score representing vulnerability of the SES (VU_{SES})

$$VU_{SES} = \left(\frac{VD_{SUS} + VD_{CAR}}{2}\right)$$

Calculate Hazards (H) and Exposure (E_{SES})) **of SES**

Calculate Risk of SES

Risk = H * E_{SES} * VU_{SES}

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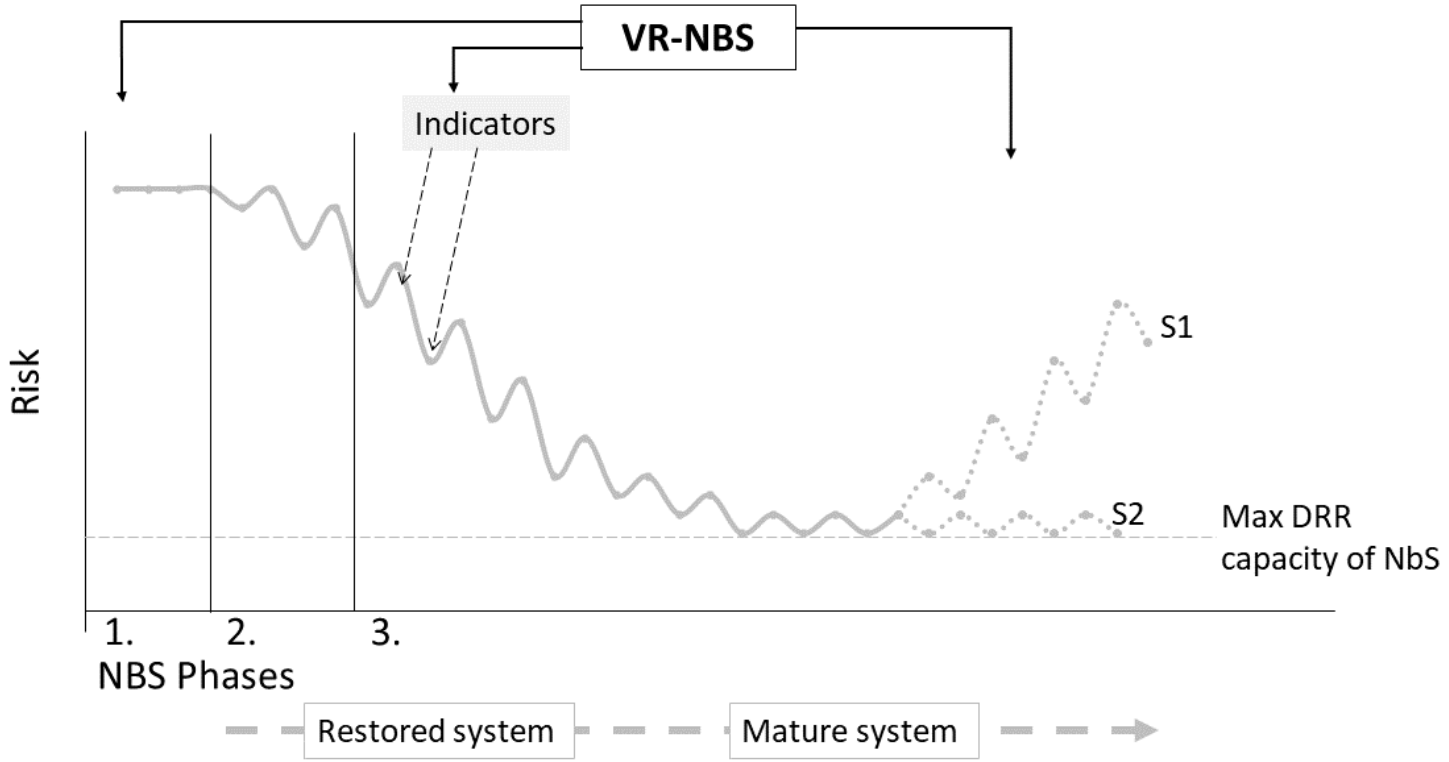
Risks at different stages of NbS implementation



1.Design and planning
2.Implementation
3.Monitoring, maintenance, and evaluation

S1. Lack of sustained monitoring and maintenance
S2. Sustained monitoring and maintenance
NbS affected by seasonal variation

Adapted from Shah, Renaud et al. (2020). A review of hydro-meteorological hazard, vulnerability, and risk assessment frameworks and indicators in the context of nature-based solutions. IJDRR, 50, 101728. [CC BY 4.0]

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Challenges for V&R assessment

- Finding suitable indicators for V&R assessment in the contexts of NBS
- Data availability for indicators (in various spatial and temporal scales)
- Primary data collection could be challenging in COVID pandemic situation, but it is vital for some indicators in case of risk assessment in very small area. Online/ remote surveys via email, phone or post could be applied.
- Since implementation and functioning of NBS may take long time, long-term monitoring of V&R indicators would be required to compare the impact of NBS on risk reduction. Proving cost and logistics could be challenging.

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Thank you!

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