

Natural Capital Approaches

Introduction to key concepts & ecosystem services
modeling tools



Charlie Weil, *Fall 2025*

Engineering a sustainable built environment, EPFL CIVIL-239

Stanford University

Charlie Weil

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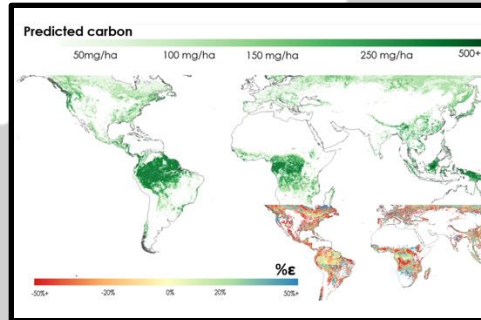
ENAC-IT4R



Stanford
University



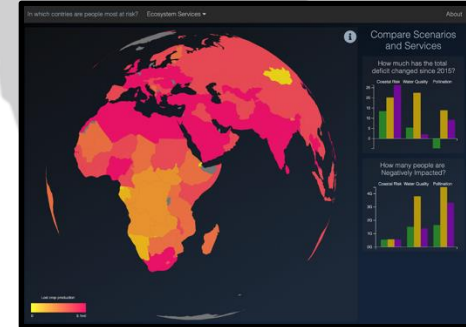
WWF



Ecosystem services
modeling
Data science



Earth
Observations
Deep learning



Data visualization

Agenda

LECTURE

- Accounting for benefits from nature ...
- ... to drive smarter landscape planning decisions

HANDS-ON

- Natural capital assessment tool: InVEST software suite
- Challenge : Run an InVEST model and interpret results

Agenda

- Accounting for benefits from nature ... (key concepts)
 - › Definitions: Natural capital & ecosystem services
 - › Supply > Service > Value
 - › NatCap Approaches : Assessment & Accounting

- ... to drive smarter landscape planning decisions (case studies)
 - › A local case study in the Amazon
 - › Global *Nature's Contribution to People* maps for politicians (IPBES)
 - › Accounting for nature with the GEP

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Natural Capital

Stock of natural assets



Ecosystem Services

Benefits people obtain from ecosystems = *Nature's Contributions to People*

Pollination



Climate regulation



Food



Clean water



Fuel



Fiber



Scenic views



Coastal protection



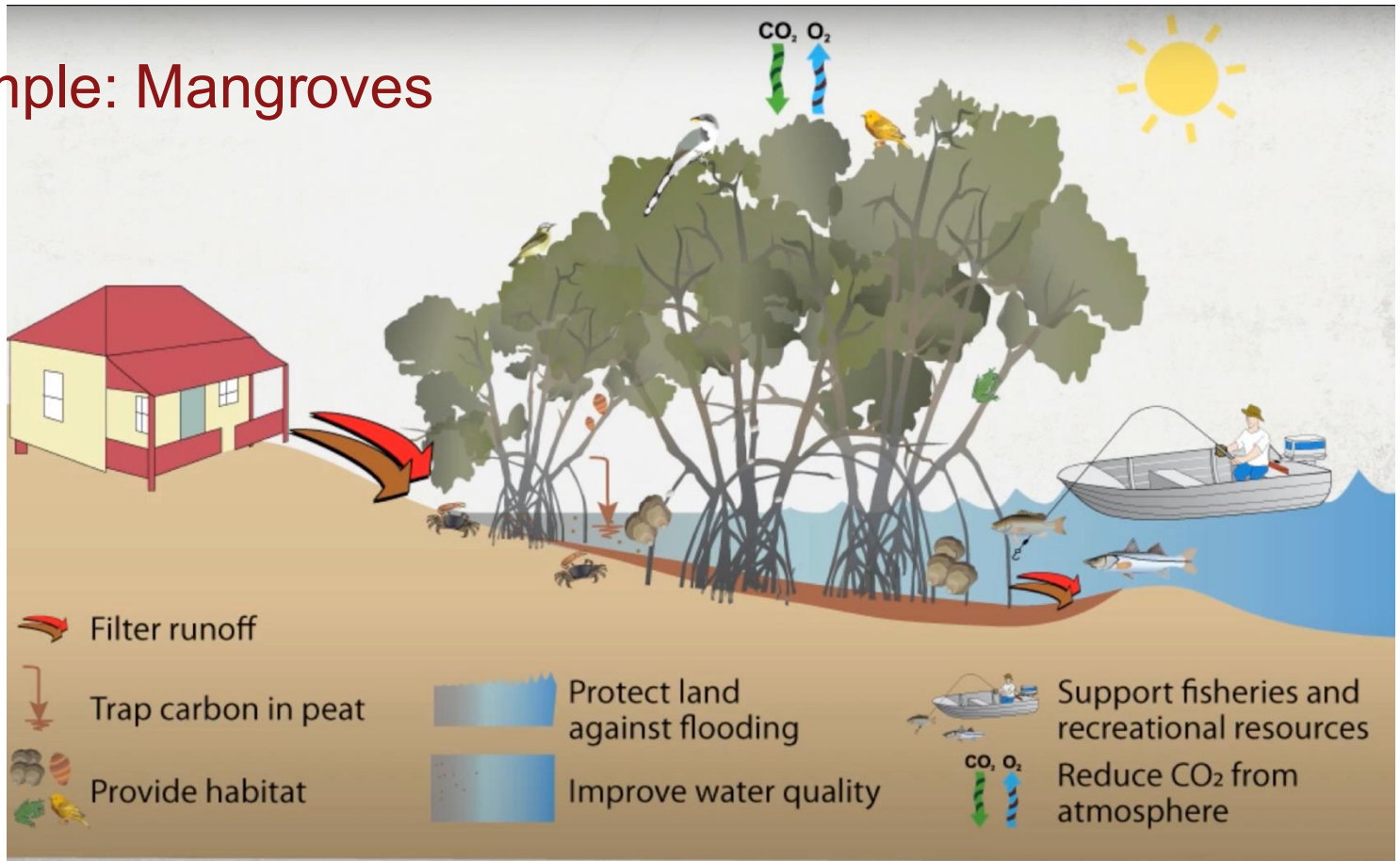
Spiritual fulfilment



Urban cooling



Example: Mangroves



Conceptual diagram illustrating the important ecological functions that mangroves provide to the marine environment. Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kruczynski, W.L., and P.J. Letcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 92 pp.

Social-Ecological System

Biophysical

Human



Ecosystem Structure

Supply

Production Function

Service

Human locations & activities

Value

Social preferences

NATURAL CAPITAL APPROACHES

Explained



HUMAN WELL-BEING DEPENDS ON NATURAL CAPITAL AND THE ECOSYSTEM SERVICES THAT FLOW FROM IT.

IN DECISION-MAKING, EXPLICIT CONSIDERATION OF NATURAL CAPITAL AND ECOSYSTEM SERVICES IMPROVES OUTCOMES FOR PEOPLE AND NATURE.

An aerial photograph of a dense, lush green forest. A wide, winding river with a reddish-brown hue flows through the center of the forest, curving from the top left towards the bottom right. The text "STRETCH BREAK" is overlaid in large, white, bold, sans-serif capital letters on the left side of the image.

**STRETCH
BREAK**

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Mining expansion

La Pampa, Madre de Dios, Perú



2018

5km



Floods in Rio Branco (Brazil), 2015

Understanding local needs...

GETTING THE RIGHT PEOPLE AROUND THE TABLE

LOCAL PARTNERS

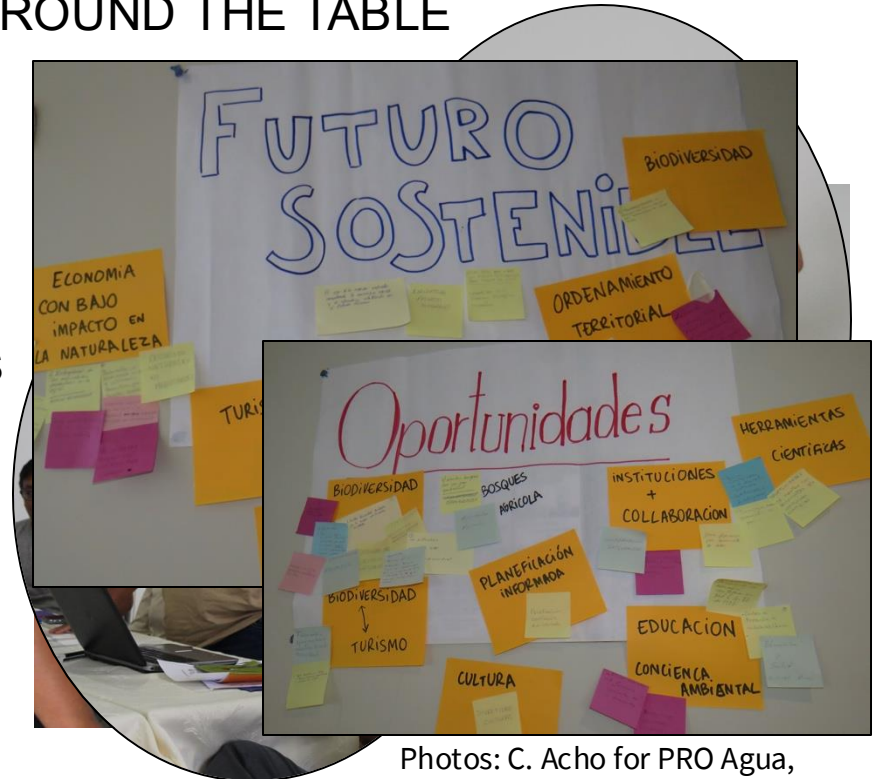
REGIONAL EXPERTS

DIVERSITY OF ACTORS

UNDERSTAND VISION AND VALUES

LISTEN

Harvesting COLLECTIVE
INTELLIGENCE

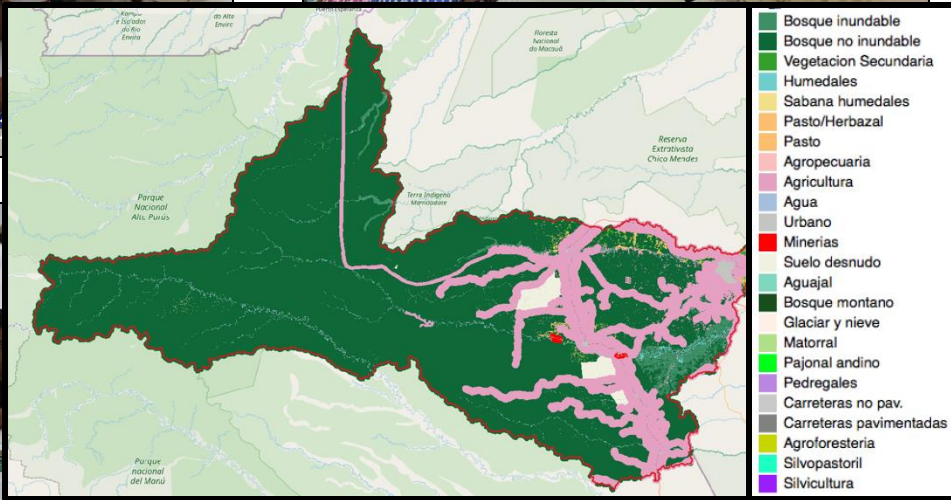


Photos: C. Acho for PRO Agua,
Puerto Maldonado 2018

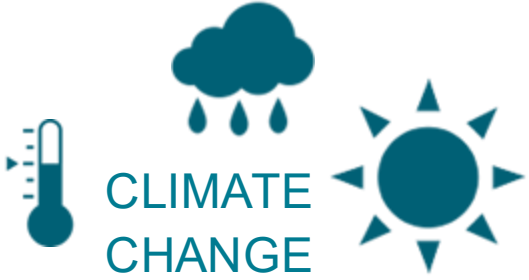
SCENARIOS co-creation



o for
ado



MODELING



CLIMATE
CHANGE



WATER
FLOWS

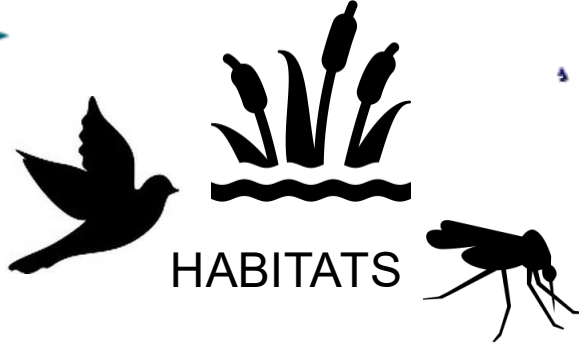
WATER
QUALITY



FLOODS



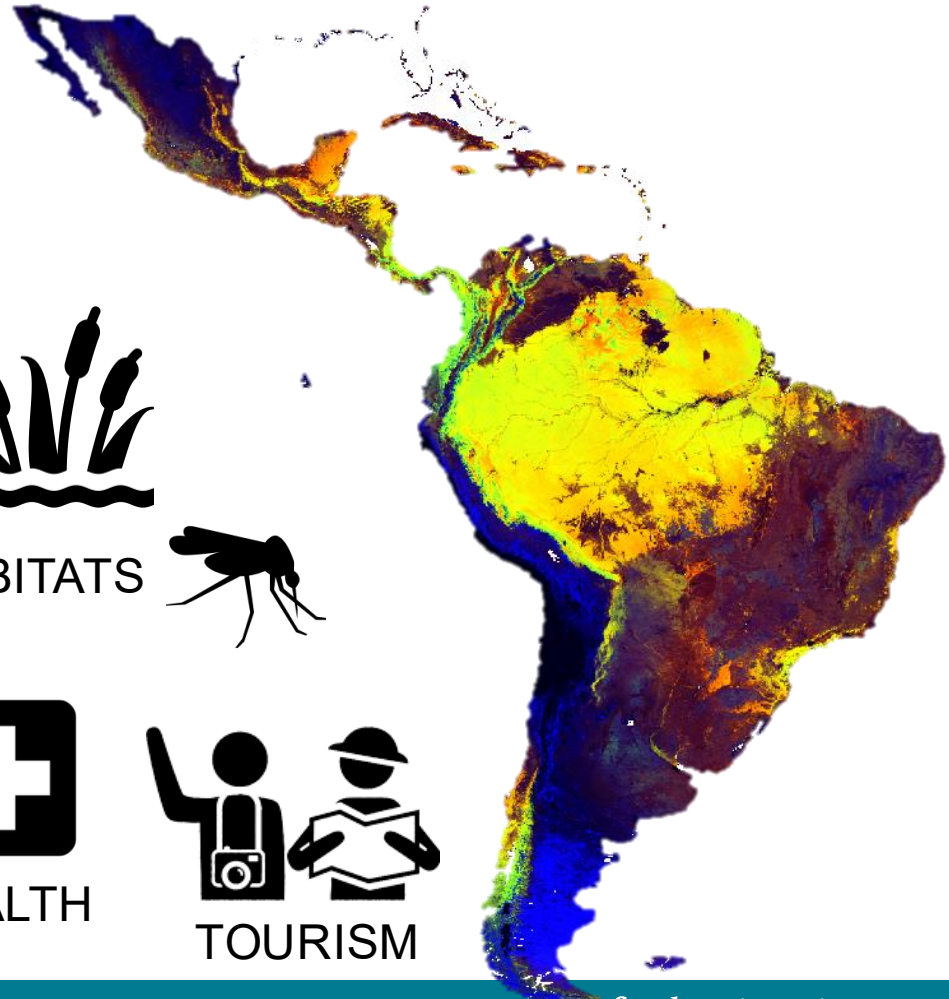
HABITATS



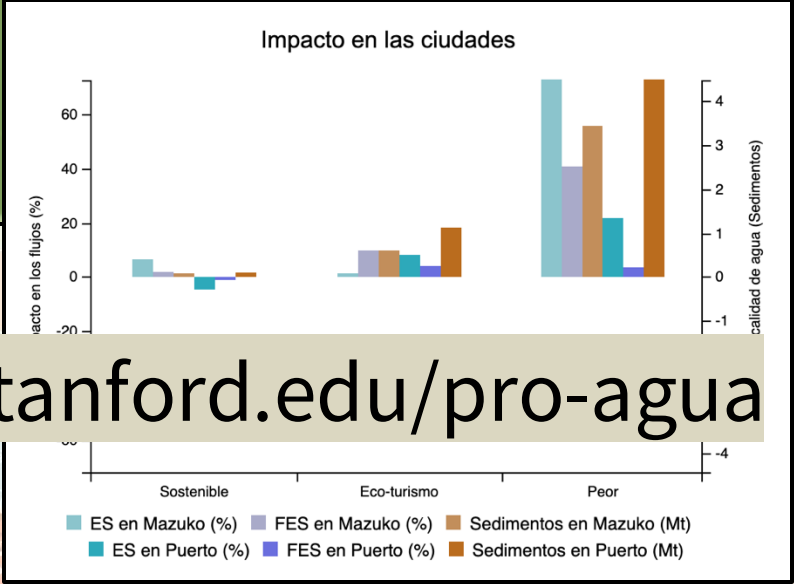
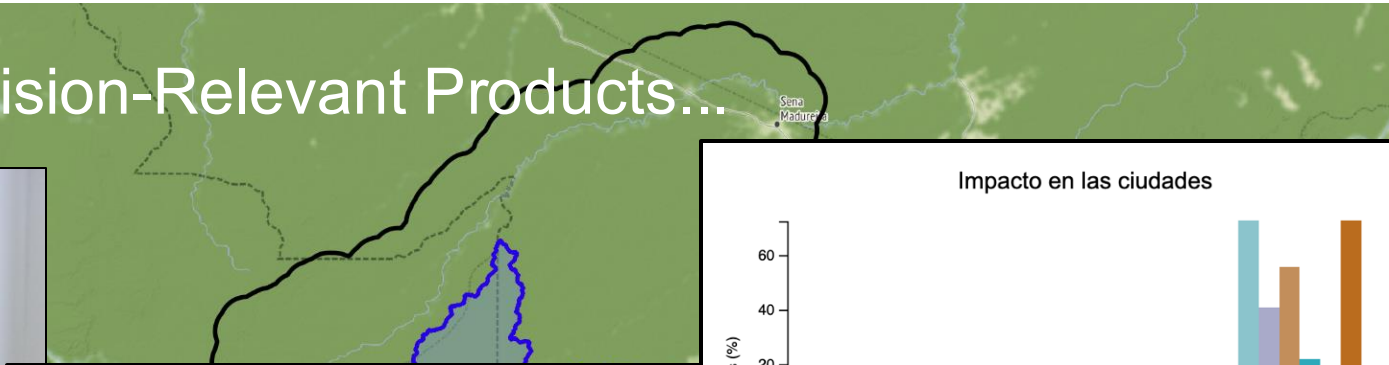
HEALTH



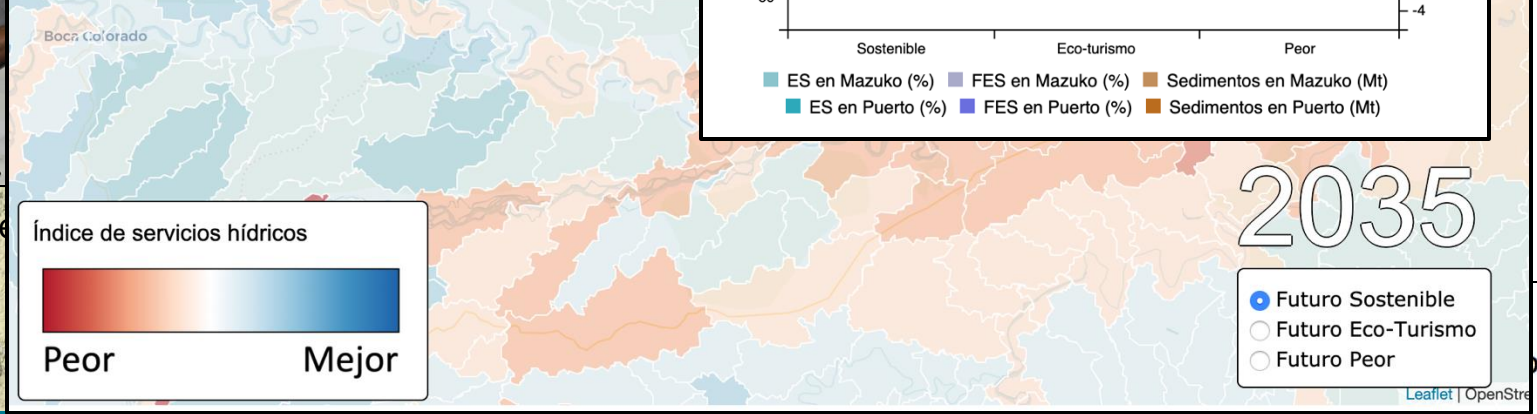
TOURISM



To Decision-Relevant Products...



viz.naturalcapitalproject.stanford.edu/pro-agua



Iñapari Mayor José Cardozo Mouzully



[PRO] Agua

GORDON AND BETTY
MOORE
FOUNDATION



CENTRO DE INNOVACIÓN
CIENTÍFICA AMAZÓNICA

Follow us! 

facebook.com/proagua.natcap.cincia





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BREAK**

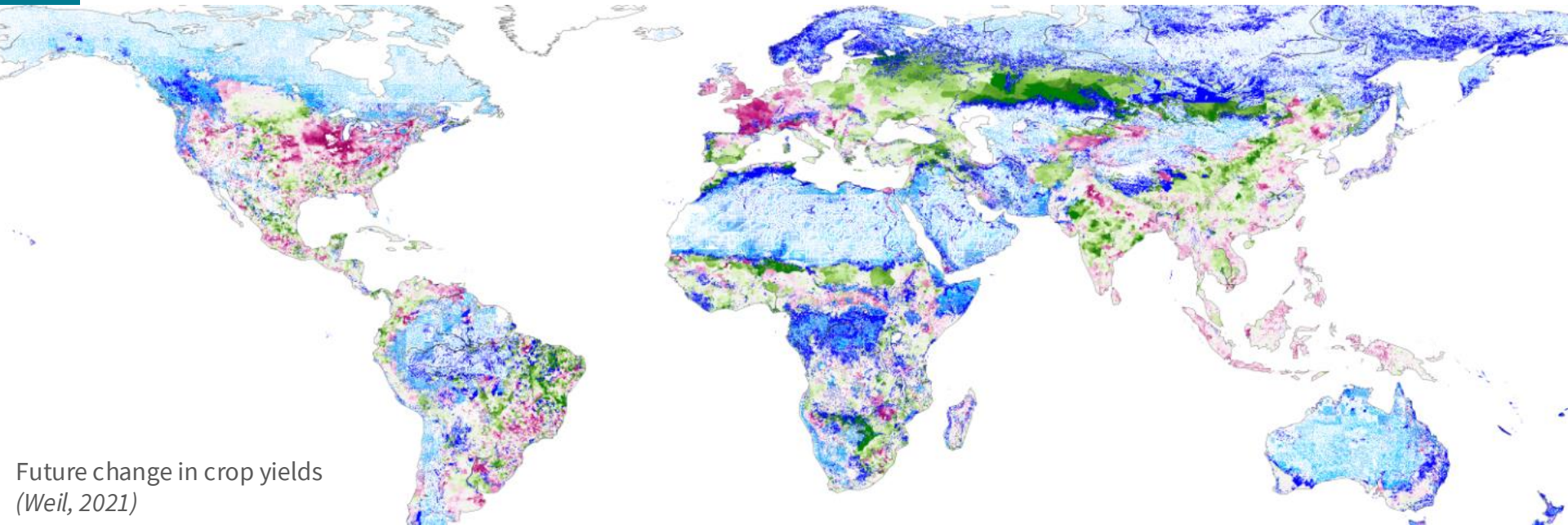
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FROM THE LOCAL

TO THE GLOBAL SCALE



Future change in crop yields
(Weil, 2021)



**Science and Policy
for People and Nature**

Where and how does nature matter most?

Paris Accord

- Where could each country invest in nature to meet their INDC's and maximize benefits to people?
- What return could be expected on those investments?



Sustainable Development Goals


- How much of a country's progress toward different SDG targets could be made through nature-based solutions?



Convention on Biodiversity

- What area-based targets for biodiversity conservation should be set if we also want to benefit people via ecosystem services?
- Where is the greatest overlap between the two?



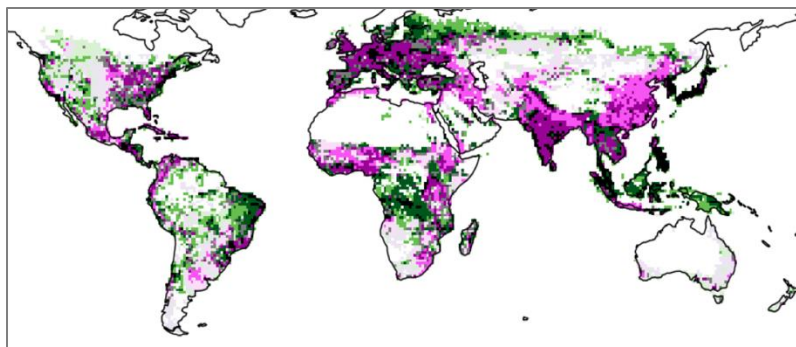
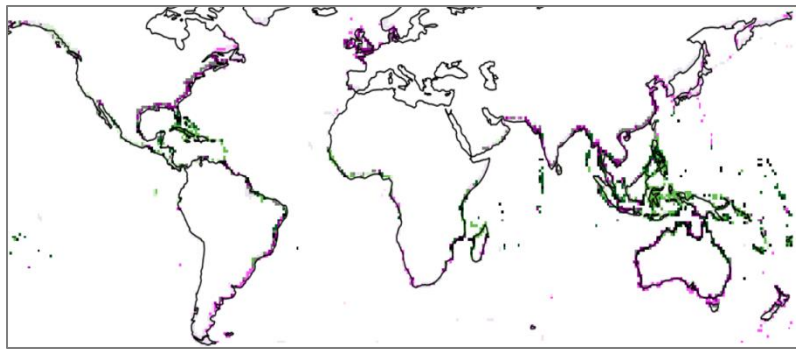
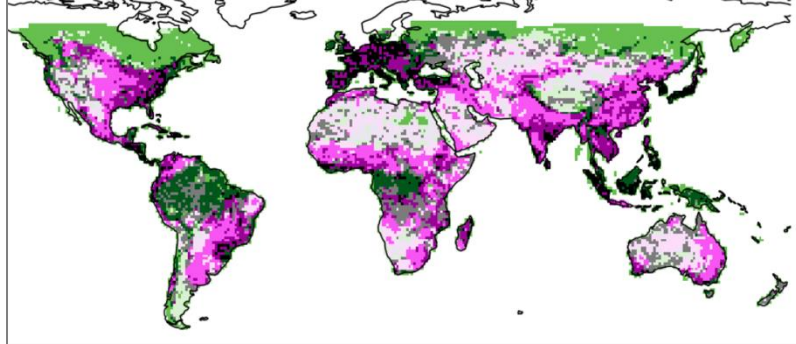
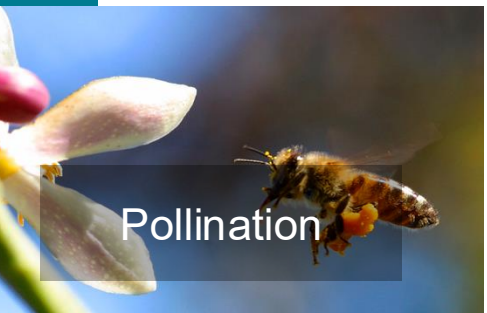


Where is nature
contributing most
to meeting
people's needs?

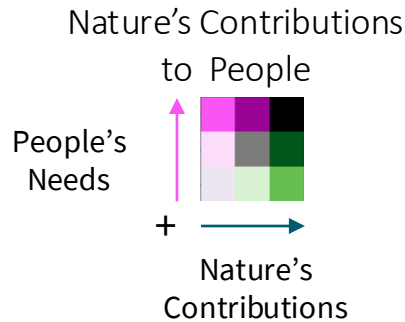
How many people
be impacted by
changes in
nature's
contributions?



ipbes

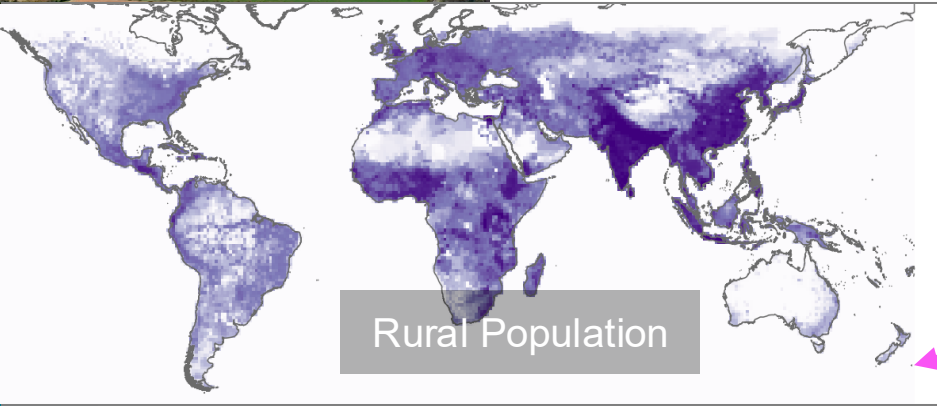


Where is nature contributing most to meeting people's needs?

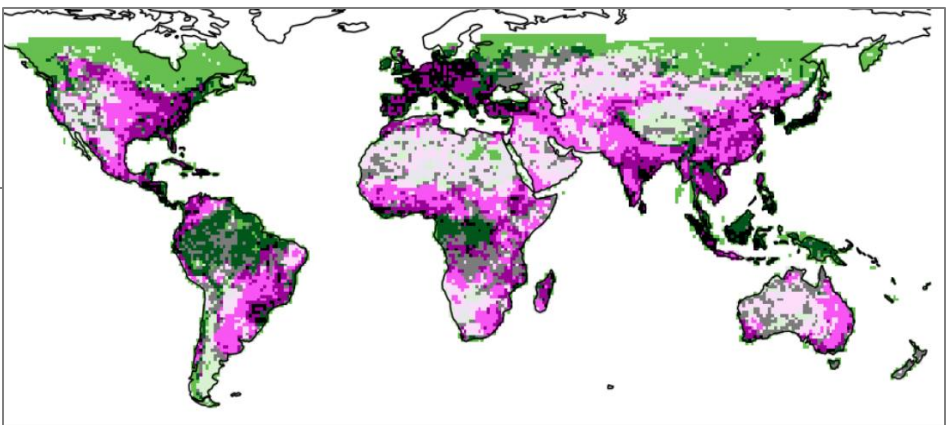




Water Quality
Regulation



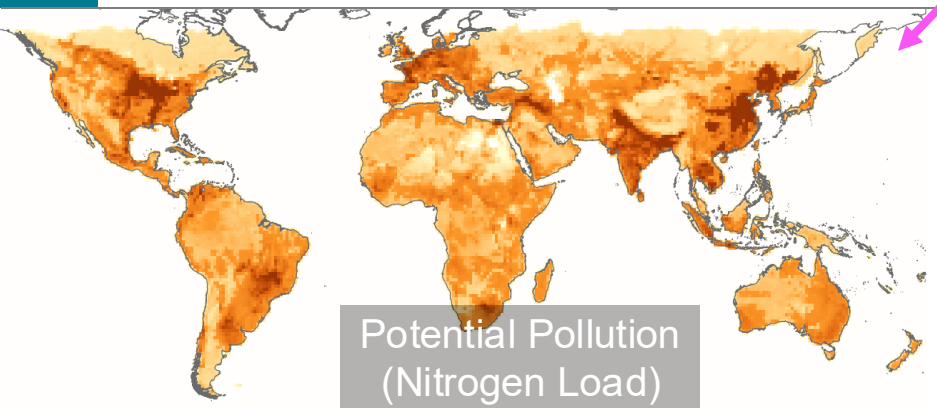
Rural Population



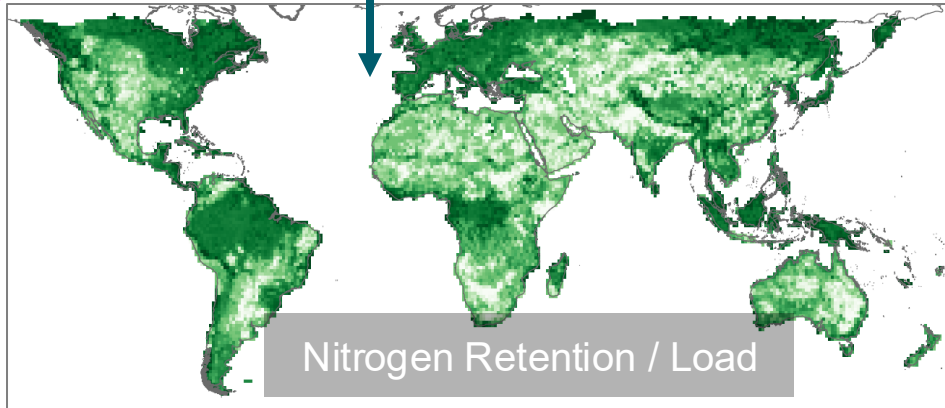
People's
Needs



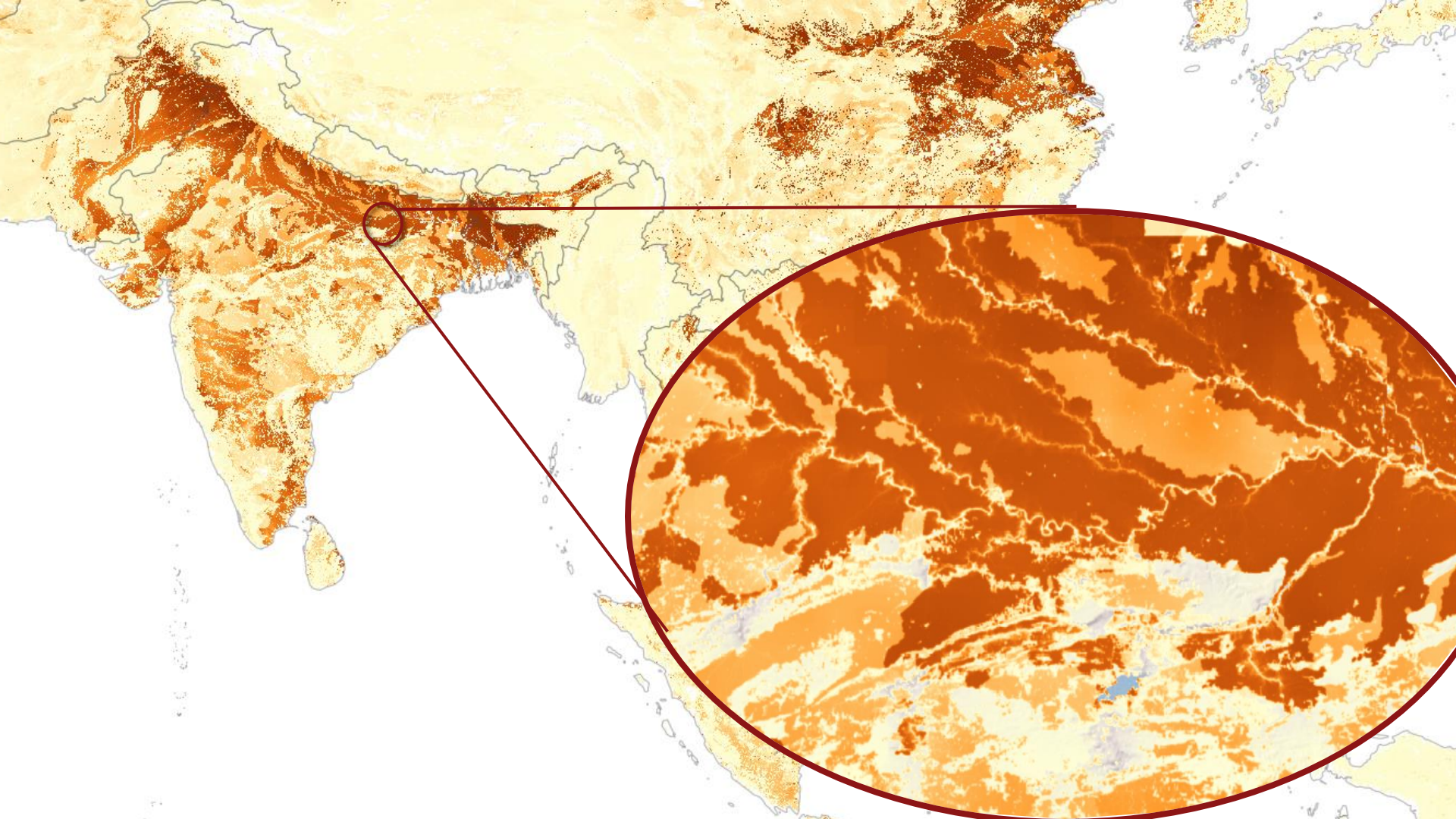
Nature's Contributions



Potential Pollution
(Nitrogen Load)

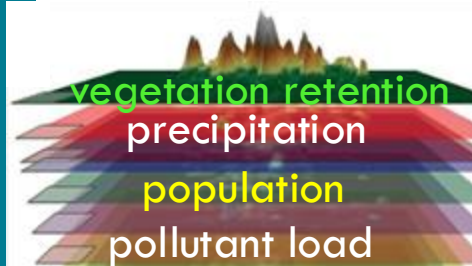


Nitrogen Retention / Load

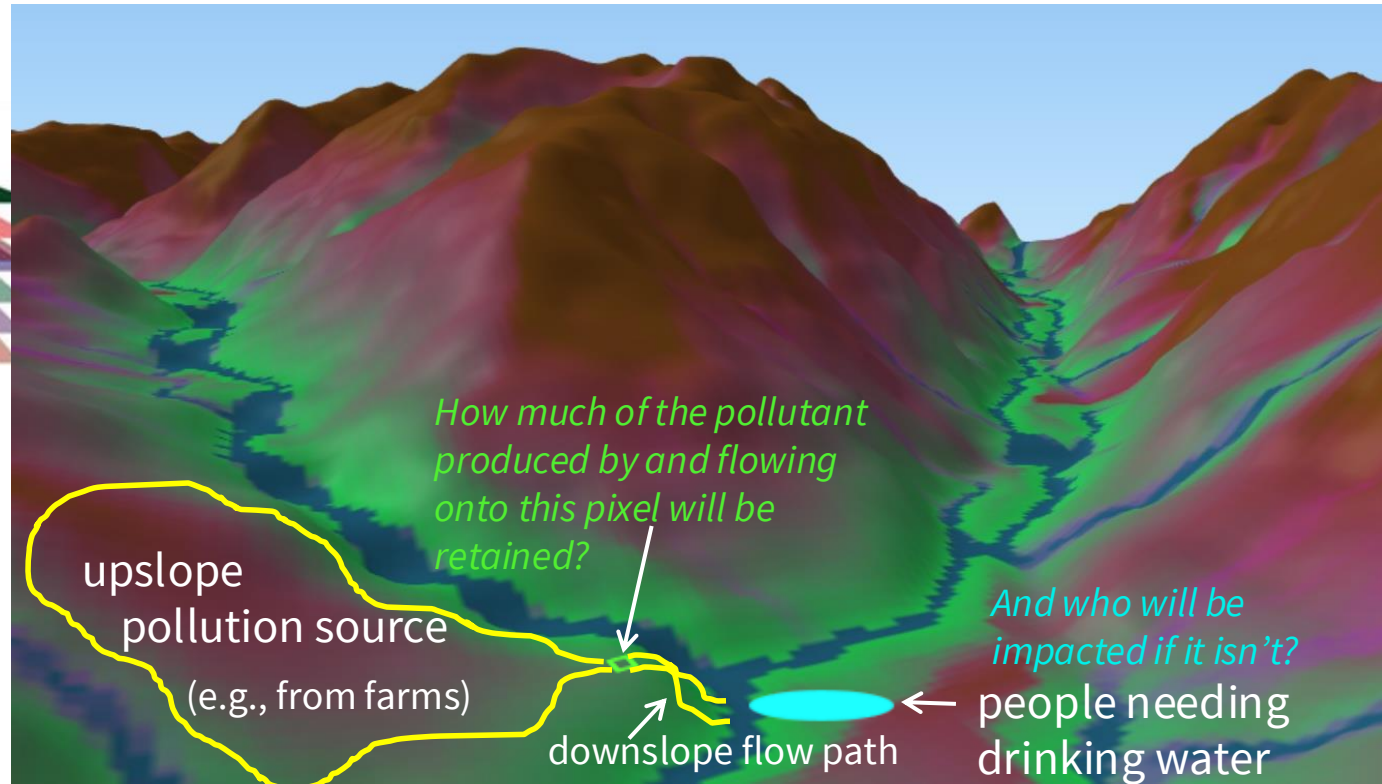
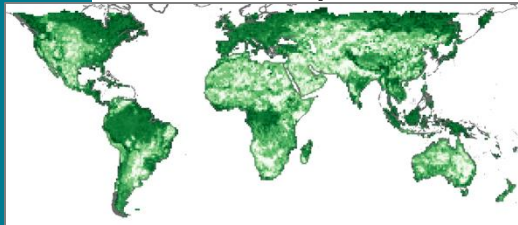


Ecosystem services: local processes

Fine-resolution
inputs to represent
local processes



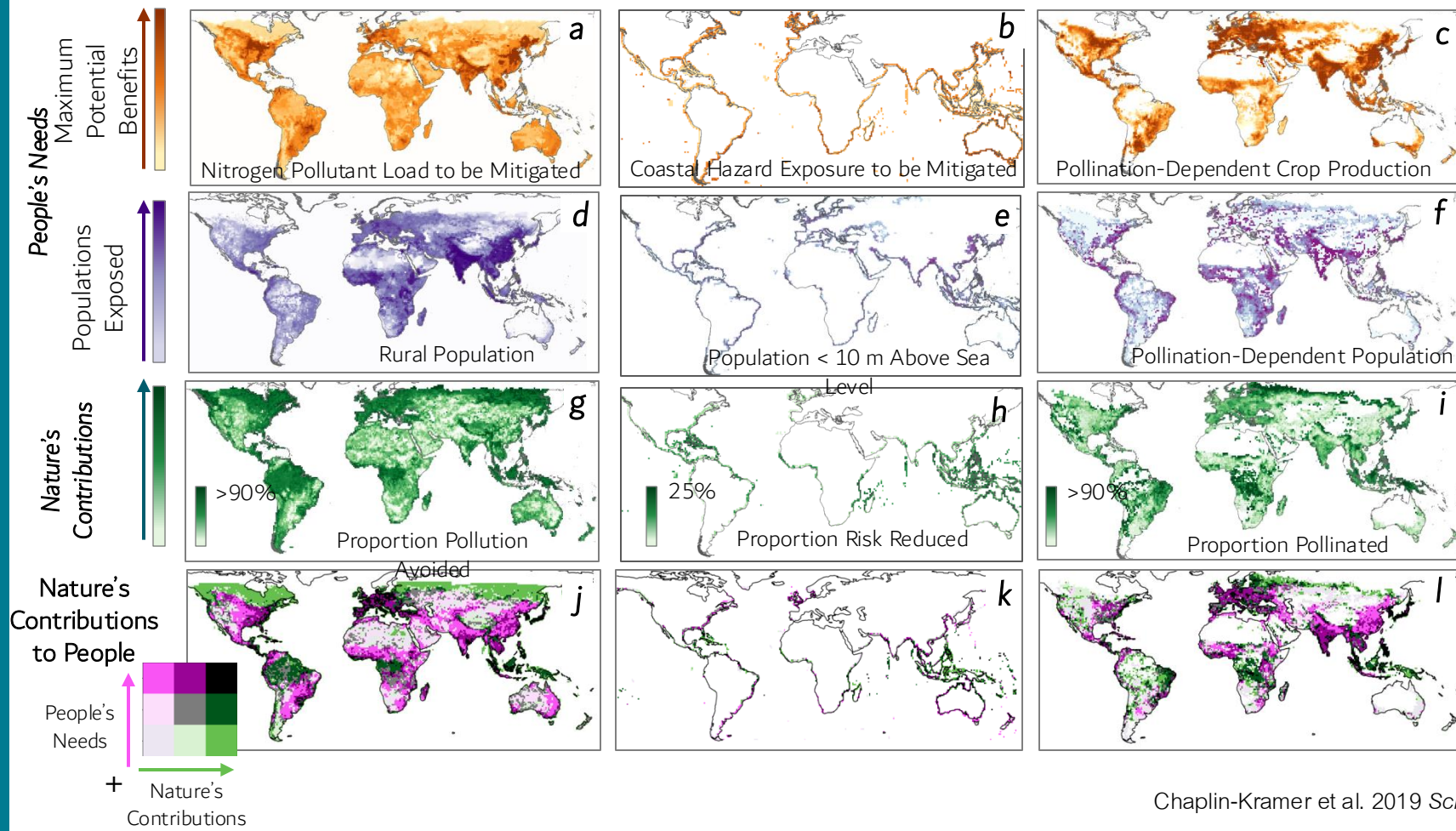
Global outputs



Water Quality Regulation

Coastal Risk Reduction

Crop Pollination



How many people may be impacted in the future?

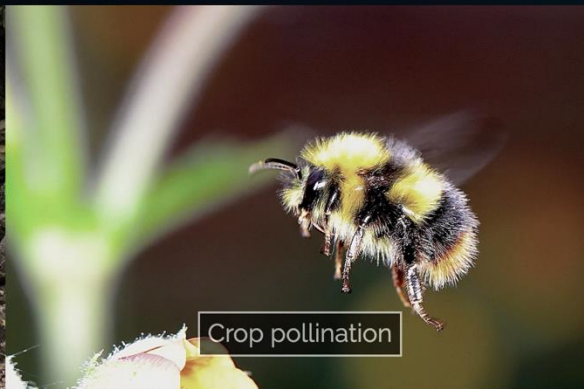


Change in:

- Population
- Demand
- Emissions
- Pollutants
- Land use
- Water use

Global Modeling of Nature's Contribution to People

An interactive viewer supporting Chaplin-Kramer et al. 2019 (Science)



Where is nature contributing to people today?

Where & how may people be impacted by 2050?



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GEP

Indicators

ECONOMY

- GDP (GROSS DOMESTIC PRODUCT) TO MEASURES A COUNTRY'S ECONOMIC PERFORMANCE

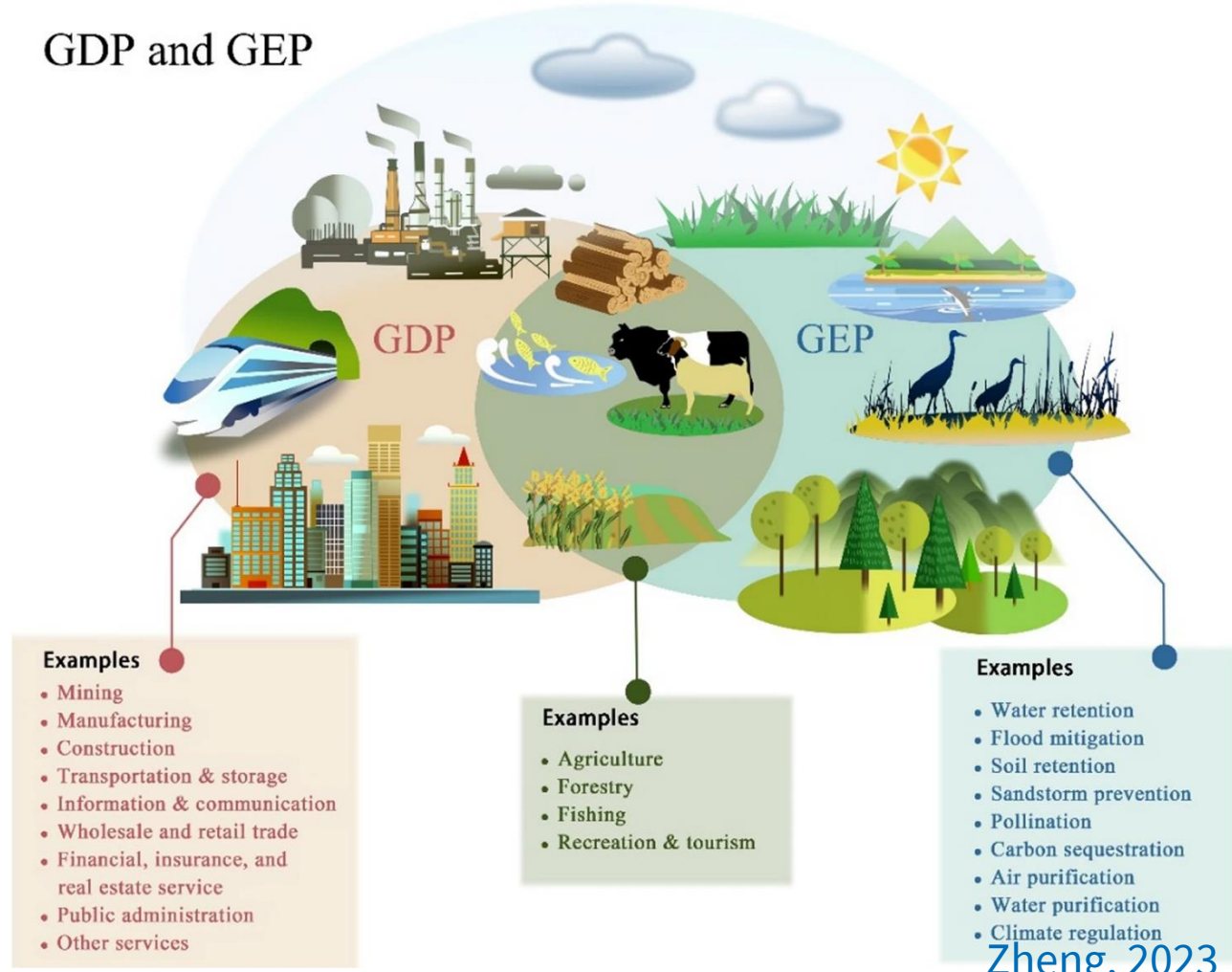
SOCIETY

- HDI (HUMAN DEVELOPMENT INDEX)
- GNH (GROSS NATIONAL HAPPINESS) TO MEASURE THE HAPPINESS AND WELL-BEING OF BHUTAN'S POPULATION

NATURE

- GEP: GROSS ECOSYSTEM PRODUCT

GDP and GEP



Examples

- Mining
- Manufacturing
- Construction
- Transportation & storage
- Information & communication
- Wholesale and retail trade
- Financial, insurance, and real estate service
- Public administration
- Other services

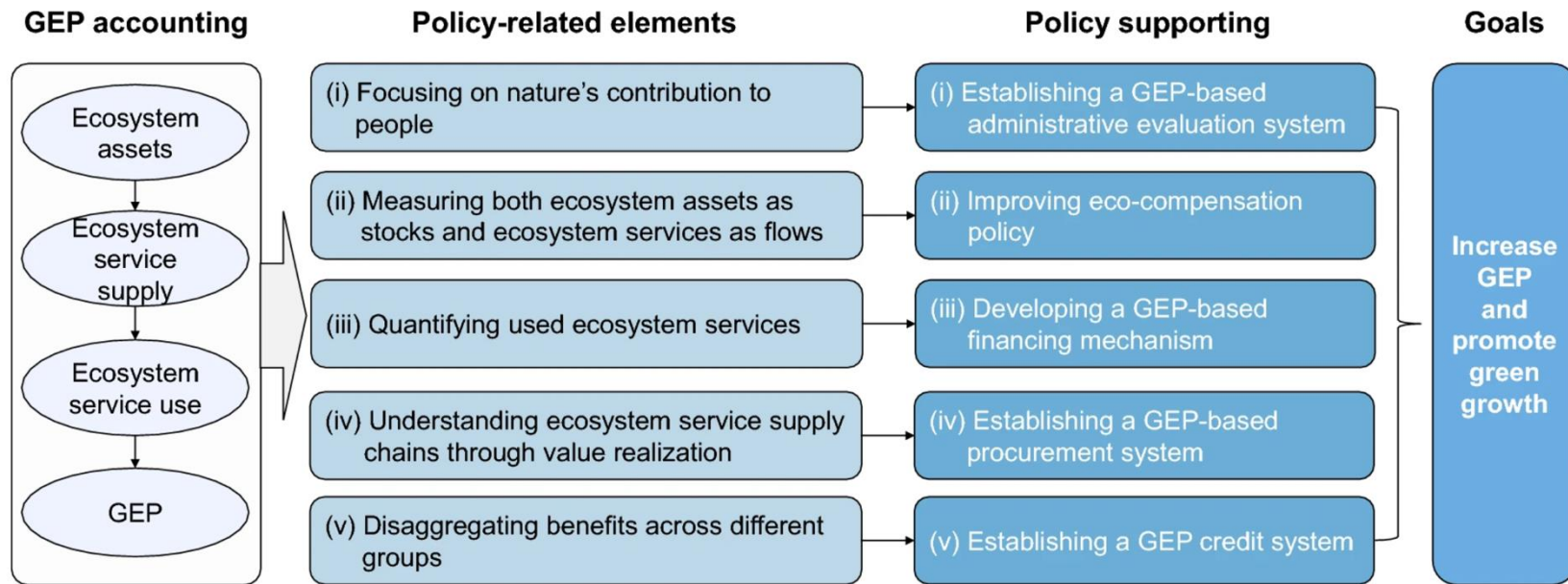
Examples

- Agriculture
- Forestry
- Fishing
- Recreation & tourism

Examples

- Water retention
- Flood mitigation
- Soil retention
- Sandstorm prevention
- Pollination
- Carbon sequestration
- Air purification
- Water purification
- Climate regulation

GEP: Implications in policies





¿ Questions ?

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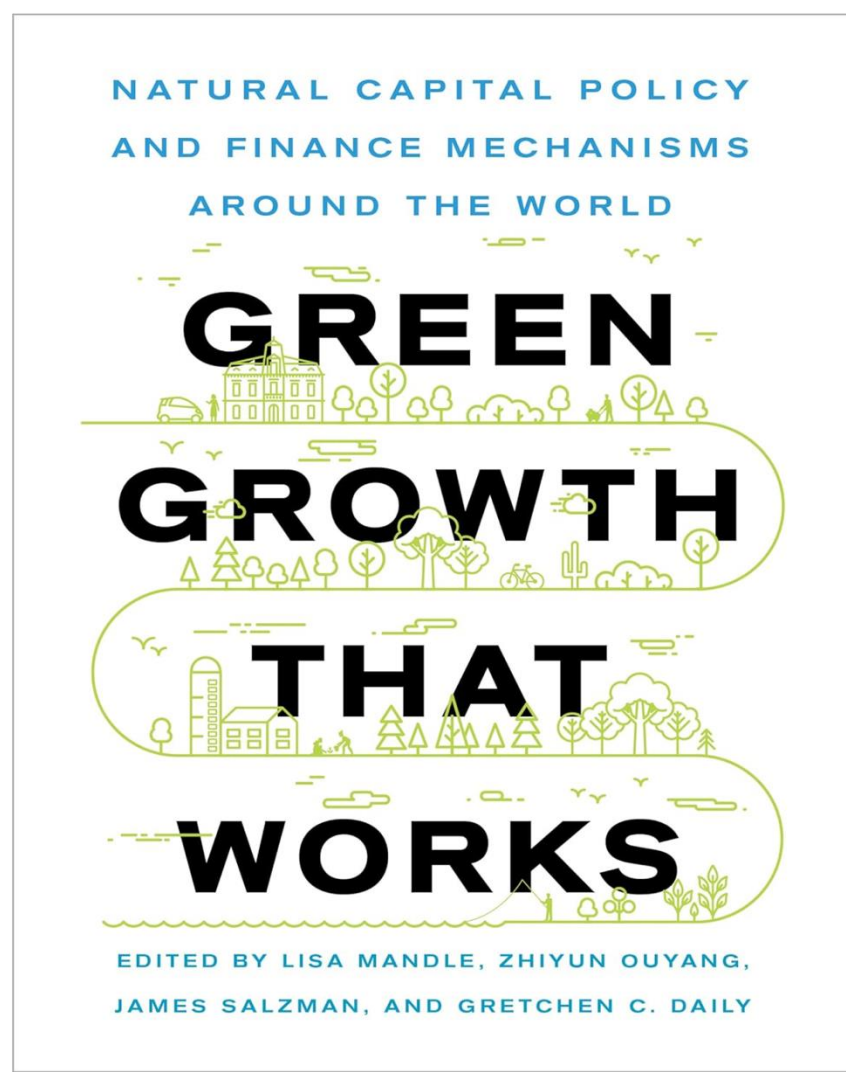
[@charlotte_weil](https://twitter.com/charlotte_weil)

Resources

NATURALCAPITALPROJECT.STANFORD.EDU

WWW.YOUTUBE.COM/@NATCAPPROJECT

BLOG POST “NATURE IS PRICELESS, SO LET'S VALUE IT” ([GUERRY, 2016](#))



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LECTURE

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- ... to drive smarter landscape planning decisions

HANDS-ON

- Natural capital assessment tool: InVEST software suite
- Assignment 5 Part 1 : Run an InVEST model and interpret results

"You can only manage what you can measure"



InVEST

integrated valuation of
ecosystem services
and tradeoffs

- Ecosystem services 'invisible' in decisions
- Need to evaluate choices, quantify tradeoffs

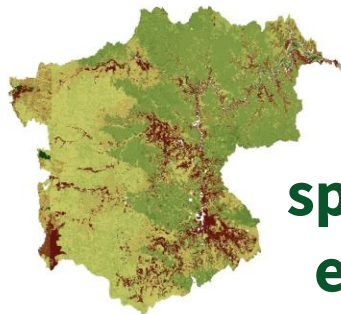
InVEST

integrated valuation of
environmental services
and tradeoffs

Simple

models + data

applicable worldwide



spatially- explicit



Endpoint of interest is
impacts to **people**



multi-service synergies/trade-offs

Open-source Free

Hands-On

TASK

CHOOSE AN ECOSYSTEM SERVICE MODEL AND RUN IT (WITH THE SAMPLE DATASETS PROVIDED, AND THE HELP OF THE USER GUIDE)

DELIVERABLE : DISPLAYING AND EXPLAINING SOME OF THE RESULTS – IN THE STYLE OF A “MEMO” FOR A LANDSCAPE PLANNING DECISION-MAKER

TOOLS

- INVEST
 - naturalcapitalproject.stanford.edu/software/invest
- QGIS
 - www.qgis.org/download/