EMBEDDING ECOSYSTEM SERVICES INTO POLICY (EESP)
LEARNING SERIES

Session 1: Introduction to Ecosystem Services Assessments and Natural Capital Accounting

Day 1

about this session

This session aims to introduce and differentiate ecosystem services (ES) assessments and natural capital accounting (NCA) with a focus on Africa, particularly Malawi. It will emphasize the interconnectedness of water, food, and energy security, highlighting the relationships between ecosystem services, resources, and natural assets. The process and policy applications of approaches and models for ES assessments, such as InVEST, Seasonal Water Yield Model, Sediment Delivery Ratio Model, and Nutrient Delivery Ratio Model, will be explored. The session will also address the impact of land degradation on ecosystem services, biodiversity, and sustainable development. Practical applications of these concepts within the Malawi 2022 PES Framework and the Malawi 2063 National Development Plan will be discussed.

Keywords: Ecosystem Services Assessments, Natural Capital Accounting, biodiversity, water funds

learning objectives

- Understand and distinguish between the concepts of ES assessments and NCA.
- Demonstrate ES outcomes that would be needed to feed into national planning for Malawi (Malawi 2063, NBSAPs, PES, Water Fund).
- Demonstrate a variety of approaches for, and examples of models and quantification of ES assessments.
- Recognize and illustrate the relevance and intrconnectedness of ecosystem services across diverse sectors.

Jane Turpie

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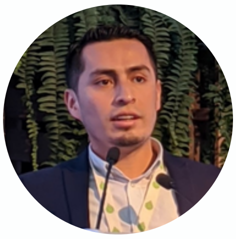
Jane is an environmental economist with 36 years of experience in conservation and development. She specializes in assessing ecosystem health, valuing ecosystem services, and integrating biodiversity into economic planning. She contributed to the development of the Millennium Ecosystem Assessment framework and the UN's Ecosystem Accounting methods. Her expertise includes water security, ecosystem rehabilitation, land degradation, and green economy development. Jane is the director of Anchor Environmental Consultants and holds a part-time position at the University of Cape Town.



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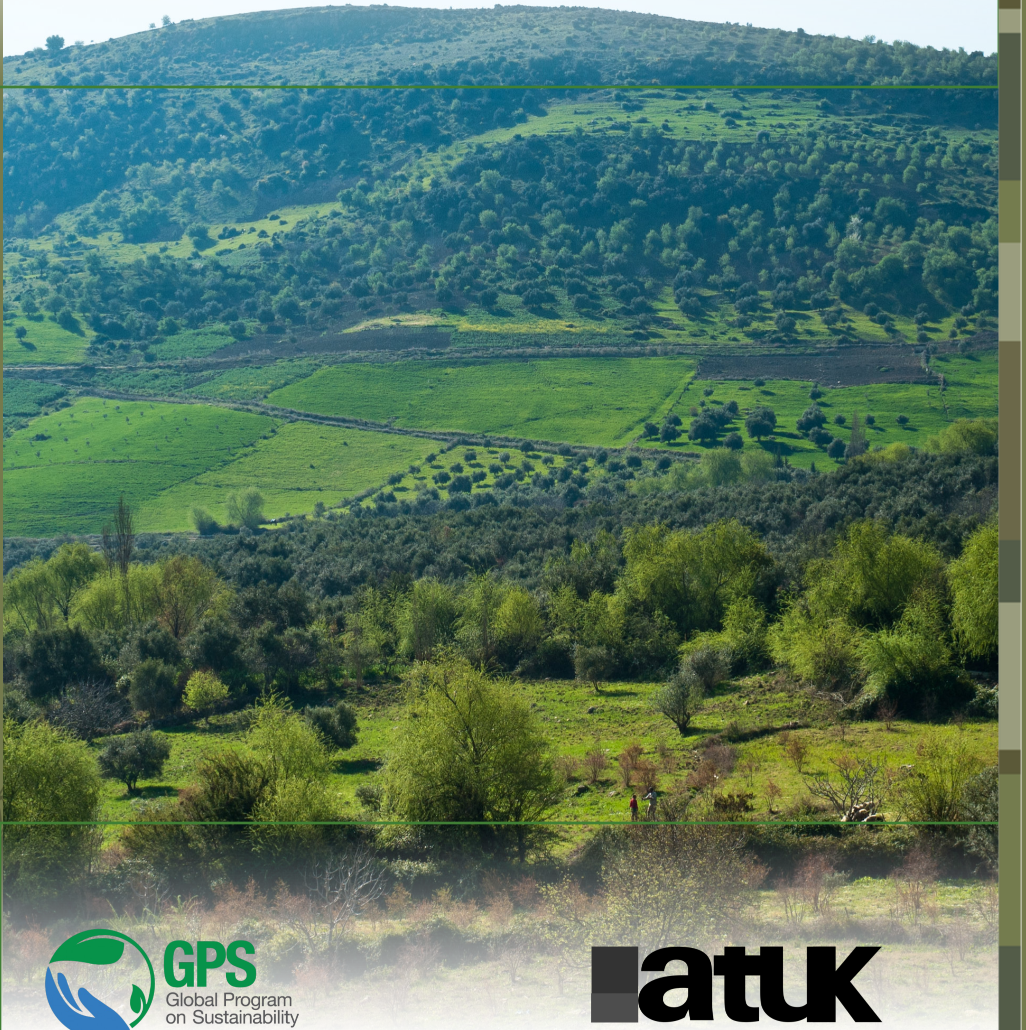
Boris F. Ochoa-Tocachi, PhD in Hydrology, is the CEO of ATUK Consultoría Estratégica and founder of the Institute for Applied Sustainability Research (iiasur). He specializes in mountain hydrology, hydrological monitoring, and ecosystem service management. As a scientific advisor for Forest Trends, he works on the "Natural Infrastructure for Water Security" project in Peru. Boris has published 40+ scientific articles, delivered 100+ presentations, and received 10 prizes and awards. His current research focuses on nature-based solutions, natural infrastructure, and engineering options for water security.

BELA Biodiversity, Ecosystems, & Landscape Assessment



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Embedding Ecosystem Services into Policy (EESP) Learning Series

Ecosystem service assessments and natural capital accounting

Boris F. Ochoa-Tocachi, PhD

ATUK Consultoría Estratégica

OBJECTIVES

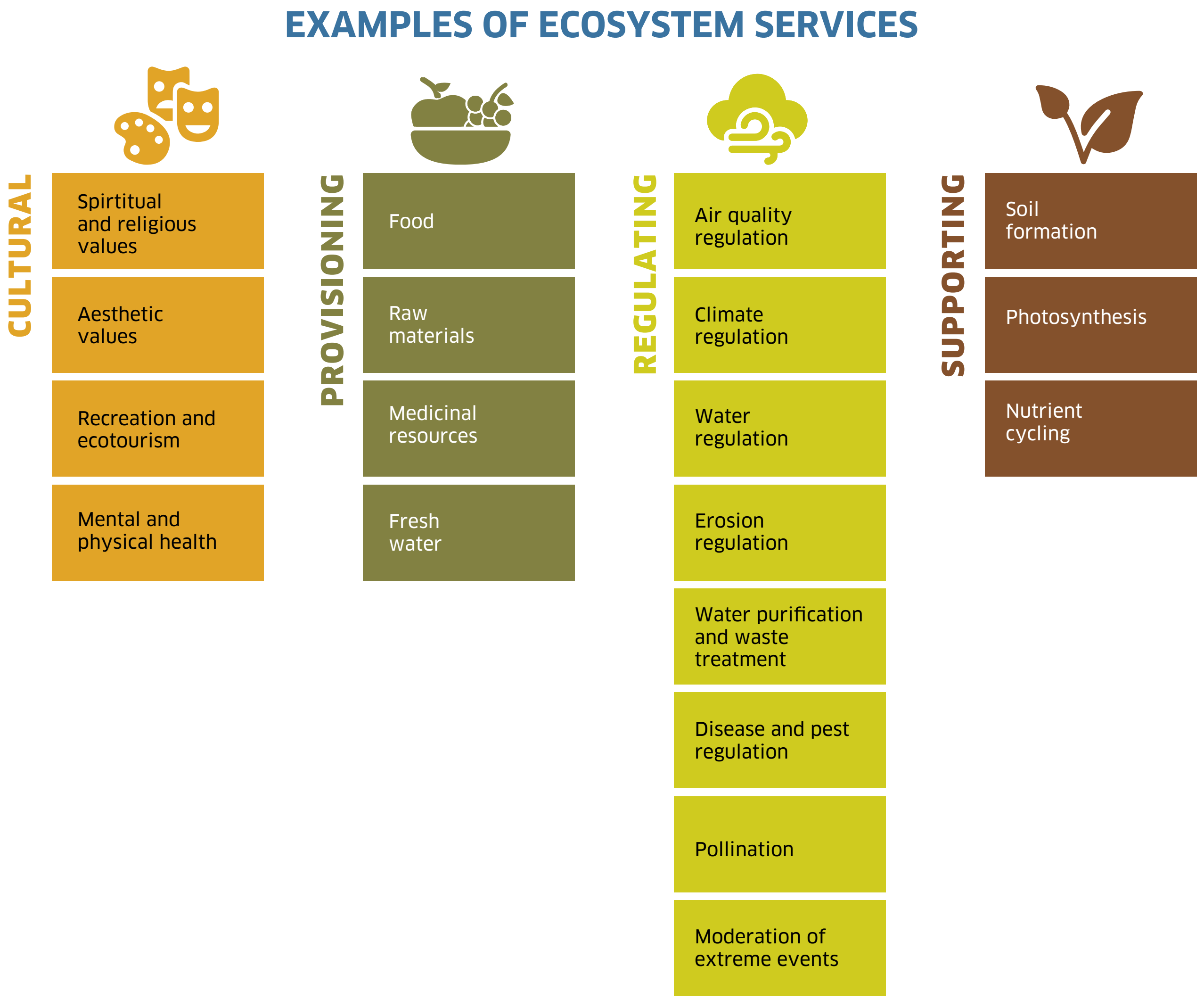
- Demonstrate the value of biodiversity, ecosystems, their services, and landscape assessments to inform more effective and climate resilient policies and planning.
- Strengthen the technical capacity of participants around ecosystem service assessments and natural capital accounting.

CONTENT

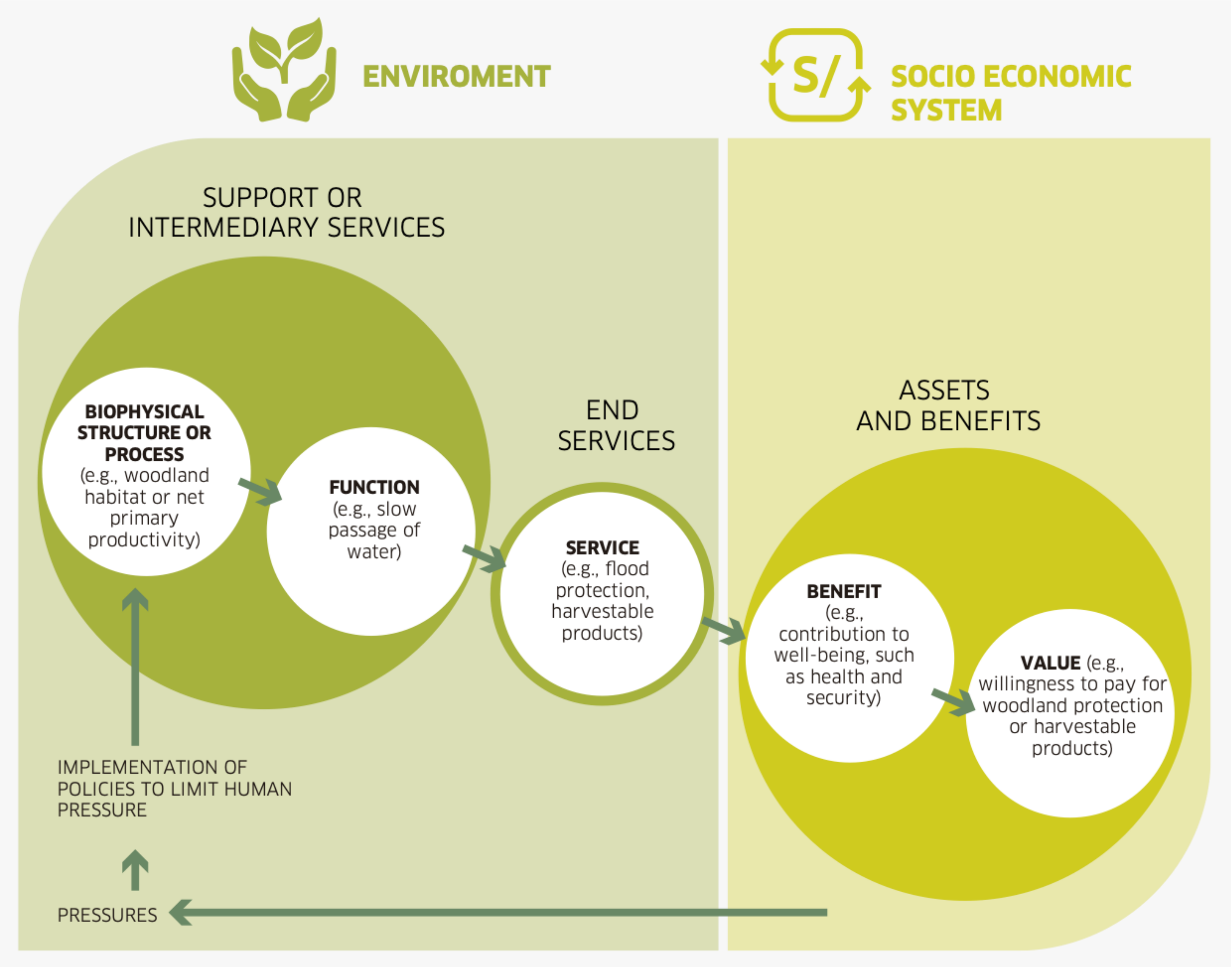
- ECOSYSTEM SERVICES
- CASCADE OF ECOSYSTEM SERVICES
- NATURAL CAPITAL
- HYDROLOGICAL ECOSYSTEM SERVICES
- WATER, FOOD AND ENERGY NEXUS
- POTENTIAL APPLICATIONS & RECOMMENDATIONS

What are ecosystem services?

- Ecosystem services are the benefits that people obtain from nature (MA, 2005).
- CICES (2018) is built on the principle that a classification of services needs to describe the contribution that ecosystems make to human well-being, defined in terms of 'what ecosystems do'.



WWF; Ochoa-Tocachi et al., 2022. Hydrological Modelling Guide for Natural Infrastructure.

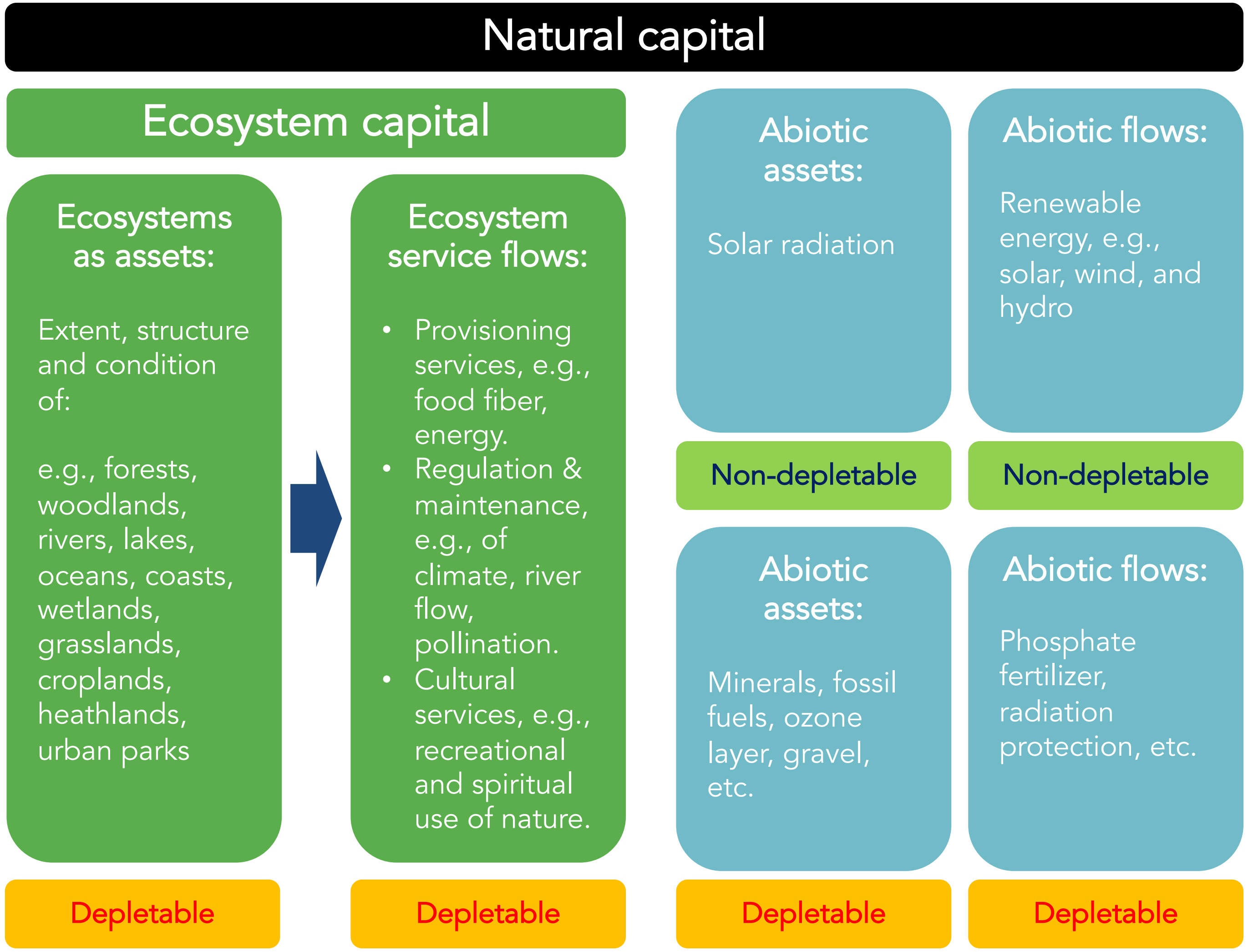


Potschin and Haines-Young, 2016; Ochoa-Tocachi et al., 2022. Hydrological Modelling Guide for Natural Infrastructure.

What is natural capital?

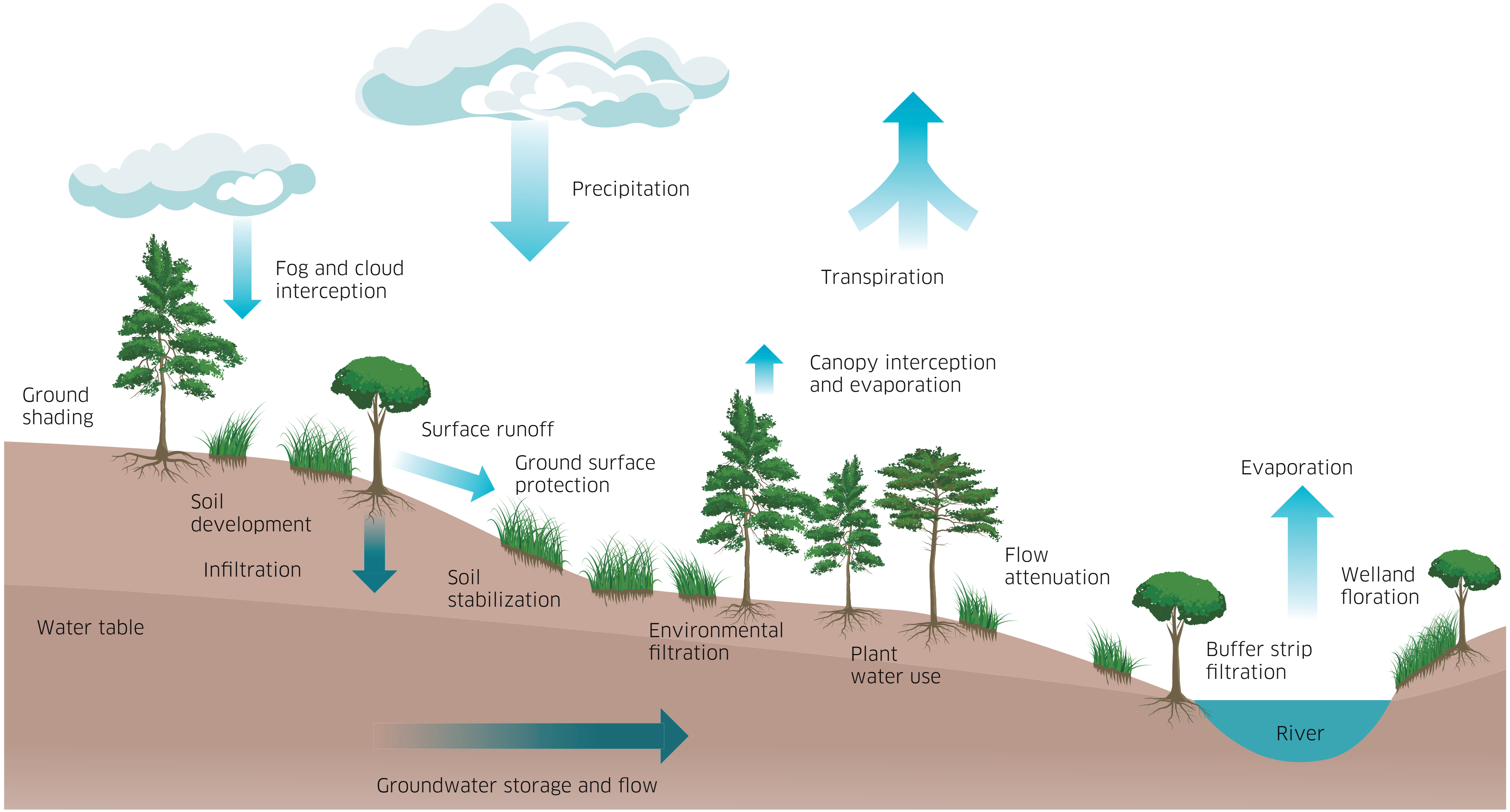
- CICES (2018) follows the European Commission (2013) process which considers natural capital to include all natural resources that human society draws upon, i.e. both earth's ecosystems and the underpinning geo-physical systems.

- For some cases, there is no clear-cut boundary between biotic (ecosystem capital) and abiotic components. However, this distinction helps identify and classify different types of natural capital, which is important in the context of developing a natural capital accounting approach.



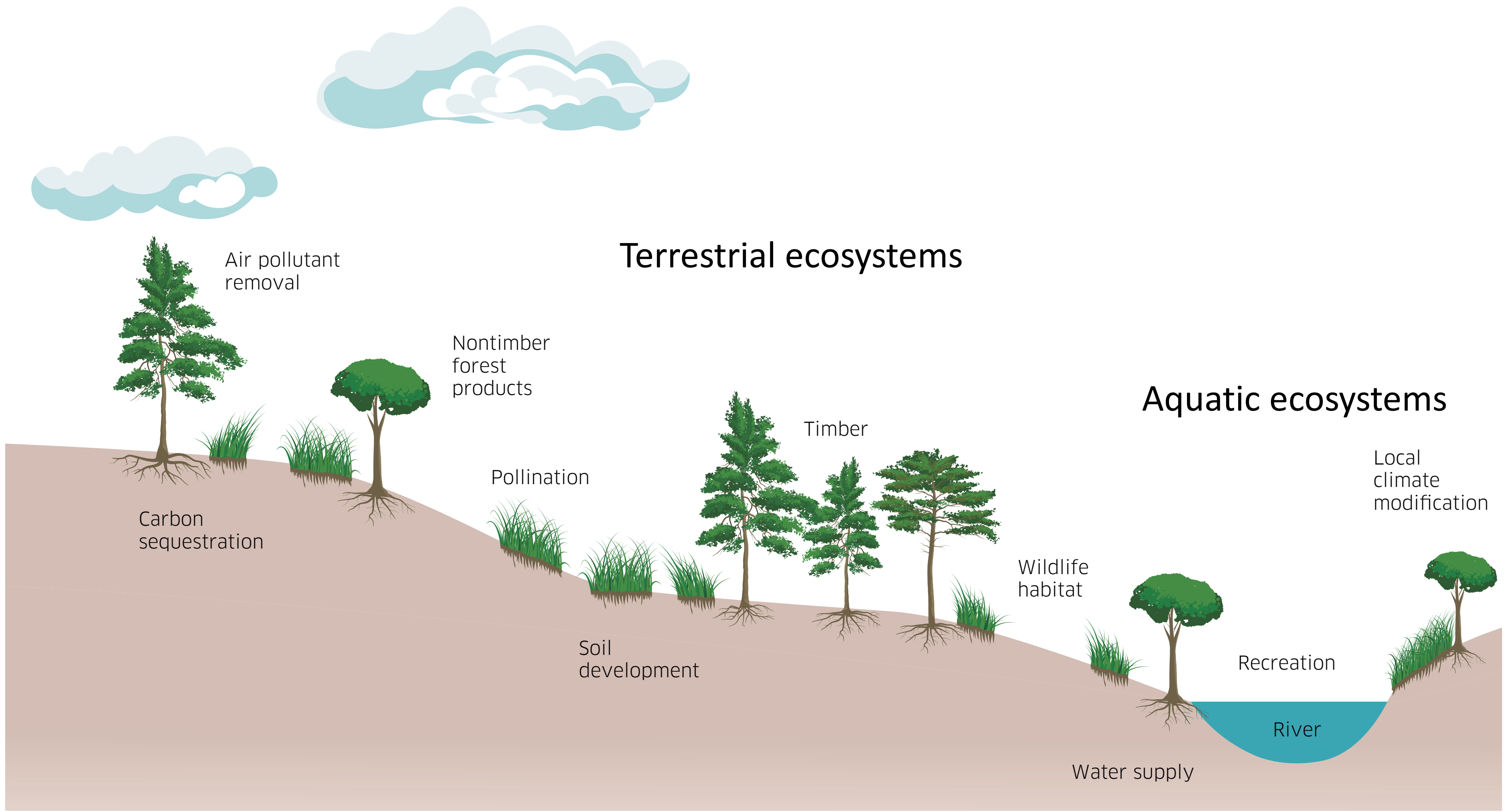
CICES, 2018.

Hydrological cycle



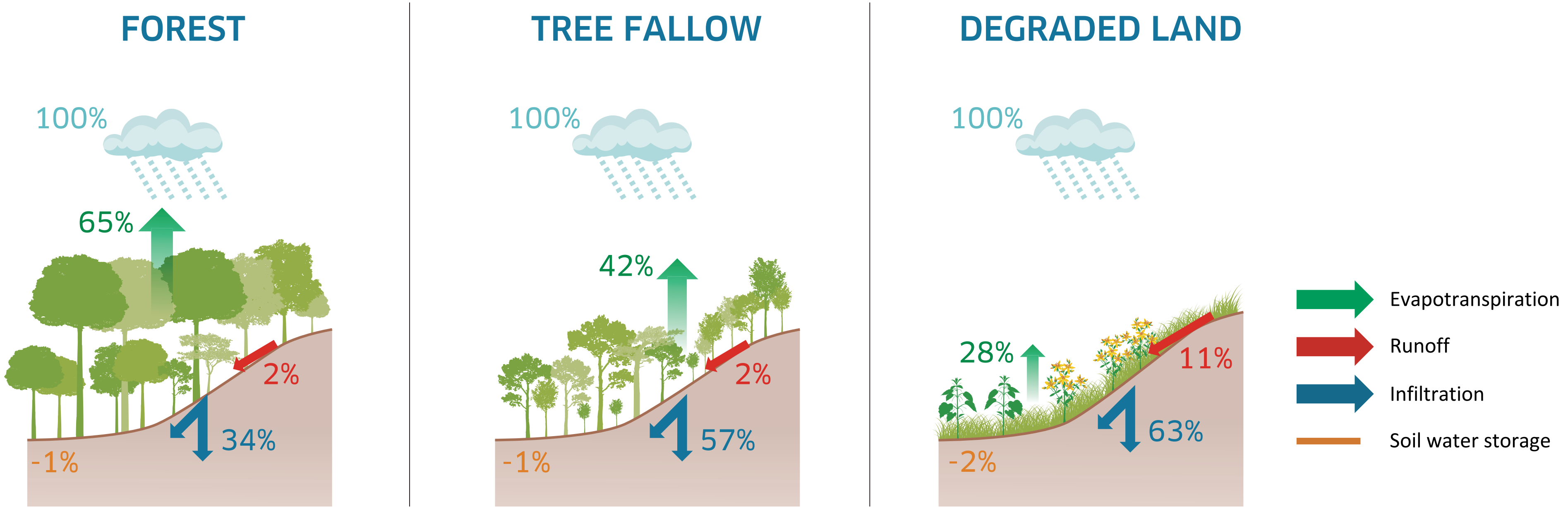
Brauman et al., 2007; Ochoa-Tocachi et al., 2022. Hydrological Modelling Guide for Natural Infrastructure.

Hydrological ecosystem services



Brauman et al., 2007; Ochoa-Tocachi et al., 2022. Hydrological Modelling Guide for Natural Infrastructure.

Ecosystems do not create water; they move and modify flows.



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Van Meerveld et al., 2021; Ochoa-Tocachi et al., 2022. Hydrological Modelling Guide for Natural Infrastructure.

Water security

- UN-Water (2013) defines water security as:

The capacity of a population to safeguard sustainable access to adequate **quantities** of acceptable **quality** water **for** sustaining livelihoods, human well-being, and socio-economic development, **for** ensuring protection against water-borne pollution and water-related disasters, and **for** preserving ecosystems in a climate of peace and political stability.

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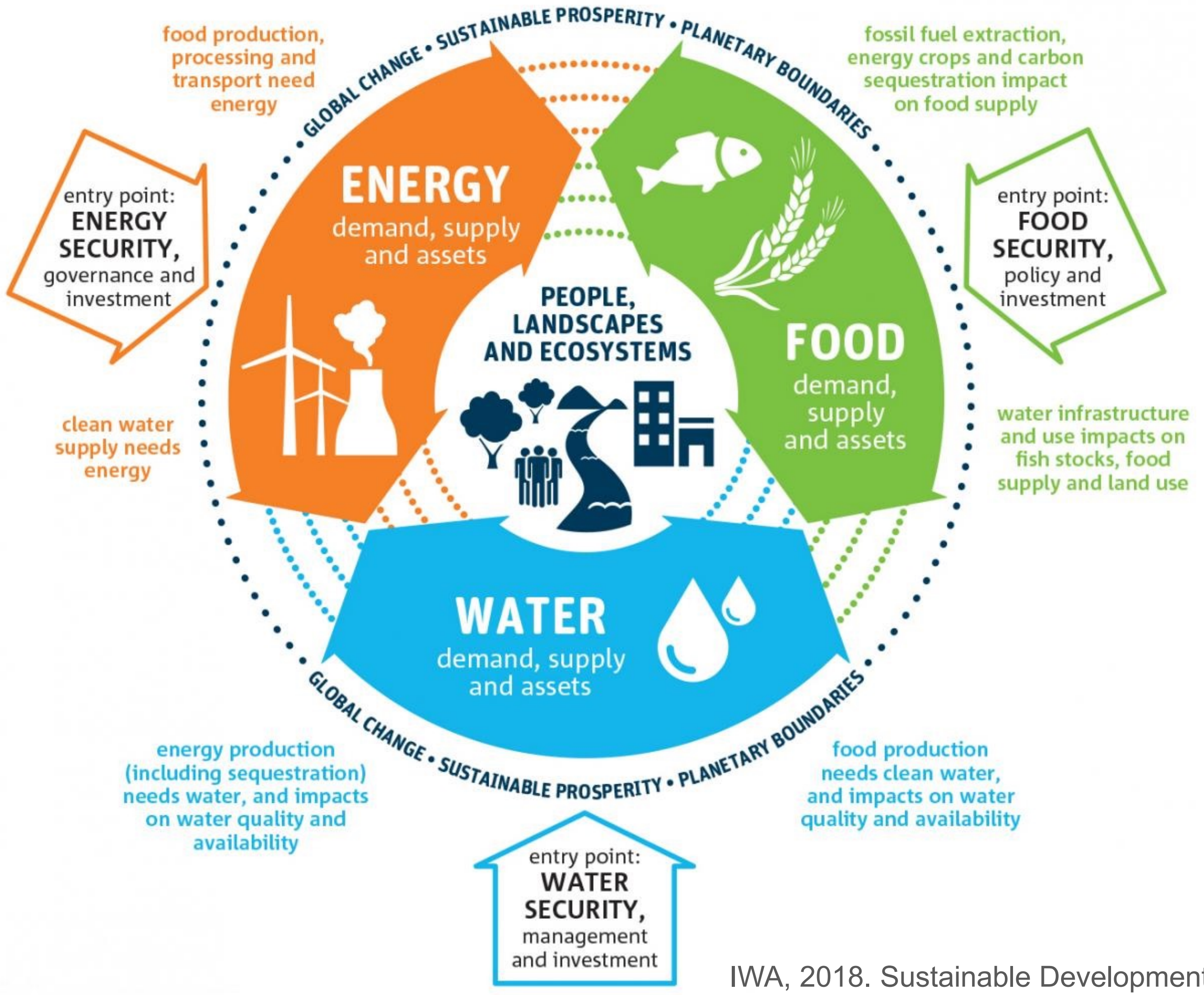
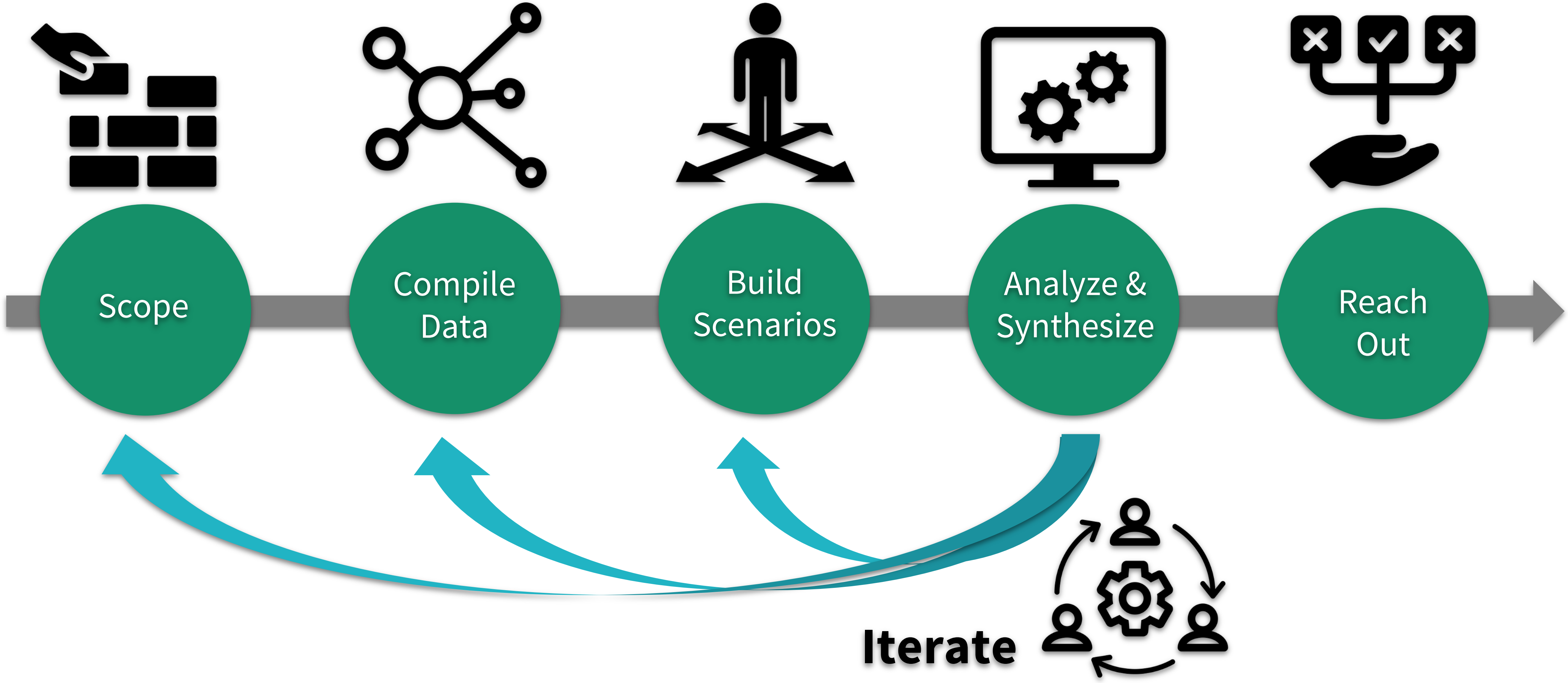
Water – Food – Energy Nexus



IWA, 2018. Sustainable Development: The Water-Energy-Food Nexus.

Climate regulation
Food, fuel, fiber
Pollination
InVEST
integrated valuation of ecosystem services and tradeoffs
Clean water
Coastal protection
Spiritual Fulfilment

Natural capital assessment process



InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs): https://naturalcapitalproject.stanford.edu/software/invest

Changes in ecosystems → Changes in ecosystem services

Seasonal water yield

Sediment delivery ratio

Nutrient delivery ratio

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InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs): https://naturalcapitalproject.stanford.edu/software/invest

Seasonal Water Yield Model

Key questions

- How much water does the landscape produce?
- From where on the landscape does this water supply originate?
- How might land management or climate change affect these contributions?
- How are we contributing to SDG6 and its indicators?

Decision contexts

Drinking water

Irrigation

Hydropower

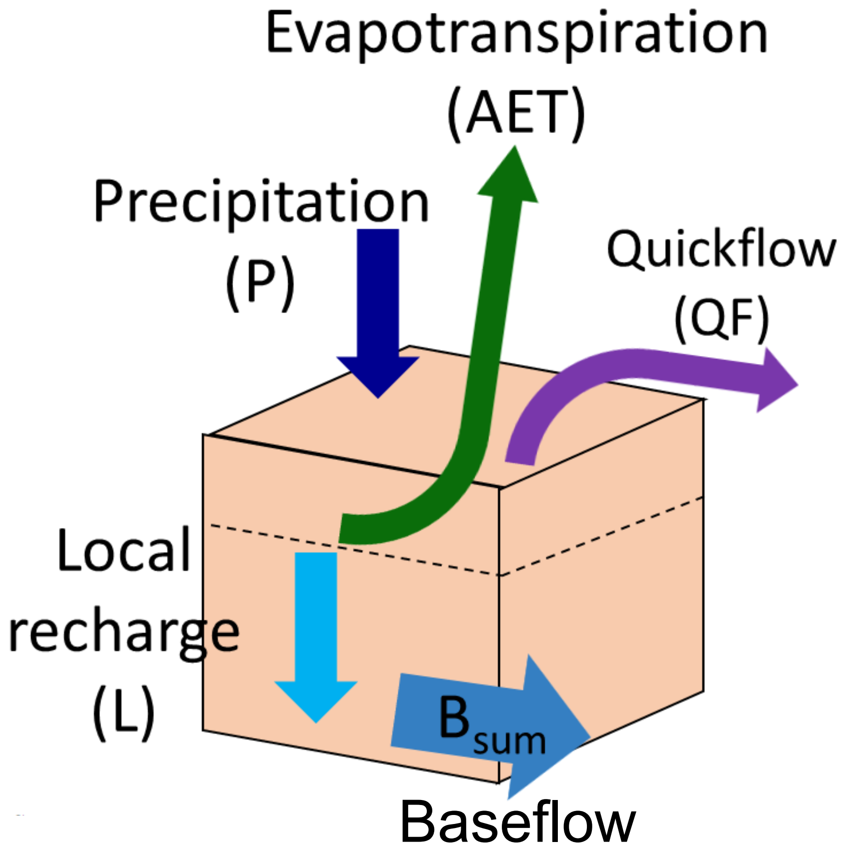
Flood risk reduction

Pollution dilution

InVEST Seasonal Water Yield: http://releases.naturalcapitalproject.org/invest-userguide/latest/seasonal_water_yield.html

SWY model

Modelled processes



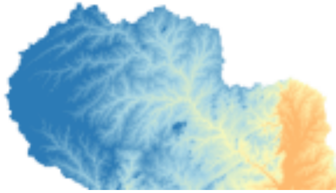
Limitations

- Results are limited to a single year long-term monthly average Quickflow and annual Baseflow.
- Baseflow is a relative index only, not absolute. It is one uniform value for the year.
- Uncertainty around flow routing (upslope contribution to AET).

InVEST Seasonal Water Yield: http://releases.naturalcapitalproject.org/invest-userguide/latest/seasonal_water_yield.html

SWY model inputs

Watershed
Area of interest

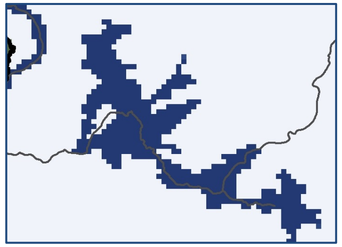


Topography
DEM,
Threshold flow accumulation

Land Use/Land Cover
Curve numbers,
Evapotranspiration coefficients

Climate (monthly)
Precipitation,
evapotranspiration,
# of rain events

Soils
Hydrologic soil groups



Optional
Climate zones,
recharge layer

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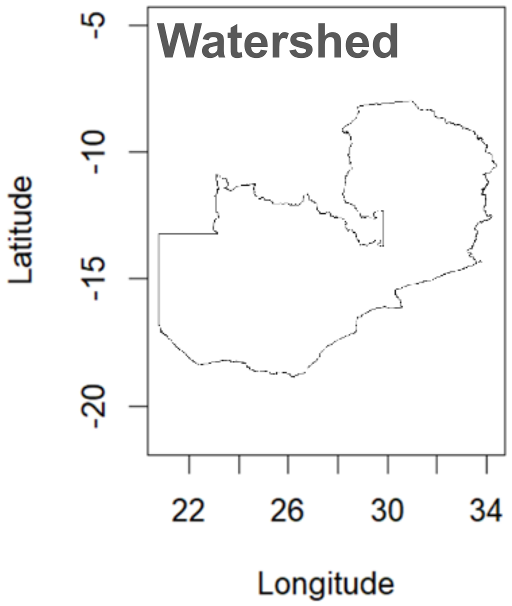
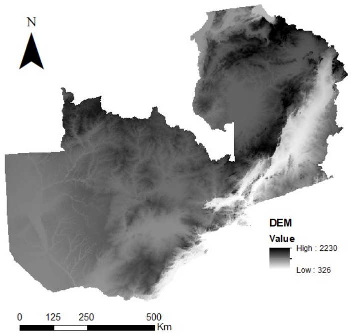
InVEST Seasonal Water Yield: http://releases.naturalcapitalproject.org/invest-userguide/latest/seasonal_water_yield.html

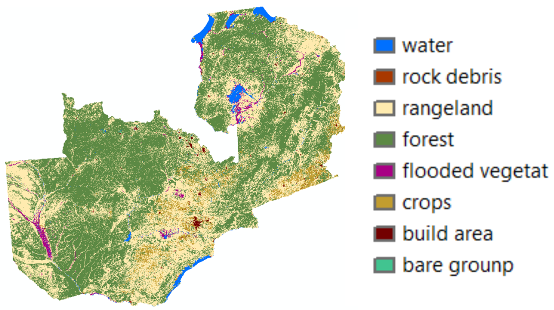
SWY model inputs



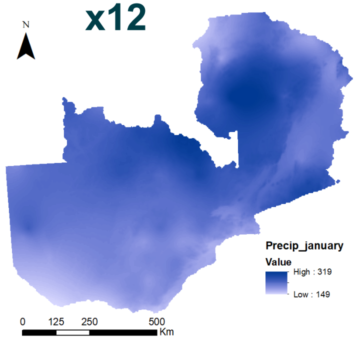
Topography



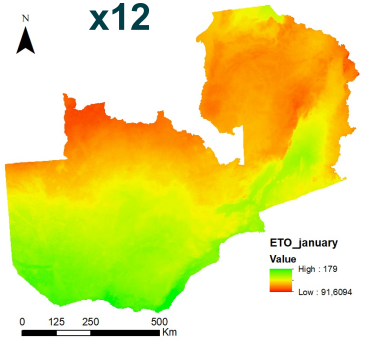
Land use / land cover



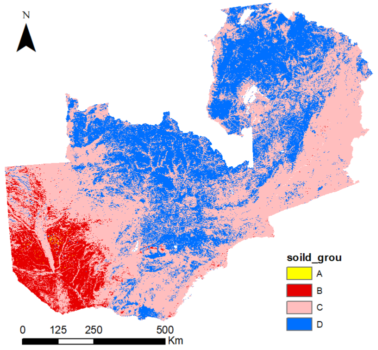
Monthly precipitation



Monthly evapotranspiration



Soil groups



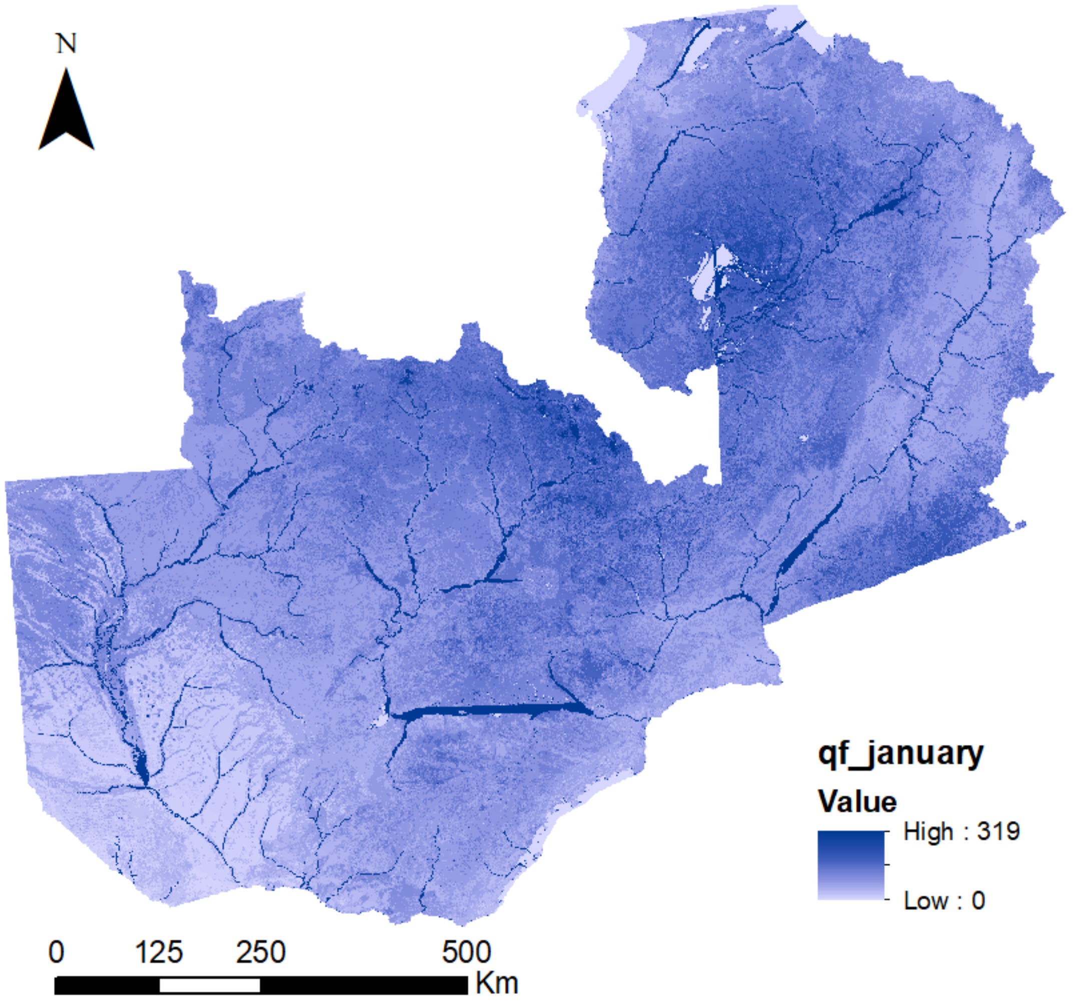
Description
A: low runoff potential (>90% sand and <10% clay)
B: moderately low runoff potential (50-90% sand and 10-20% clay)
C: moderately high runoff potential (<50% sand and 20-40% clay)
D: high runoff potential (<50% sand and >40% clay)

SWY model outputs

- **Quick flow (mm)**

Water reaching streams during or shortly after rain events (direct runoff)

Annual and monthly averages



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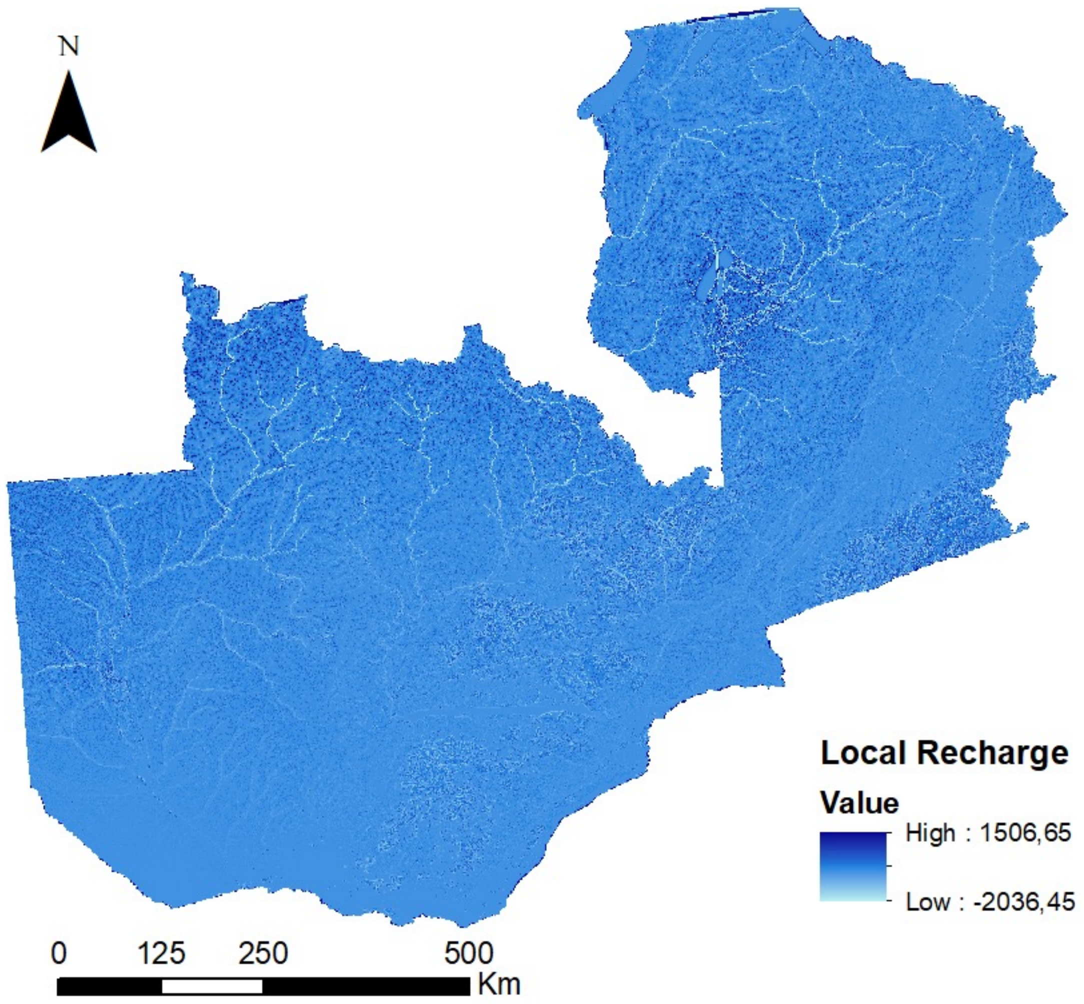
SWY model outputs

- **Local recharge (mm)**

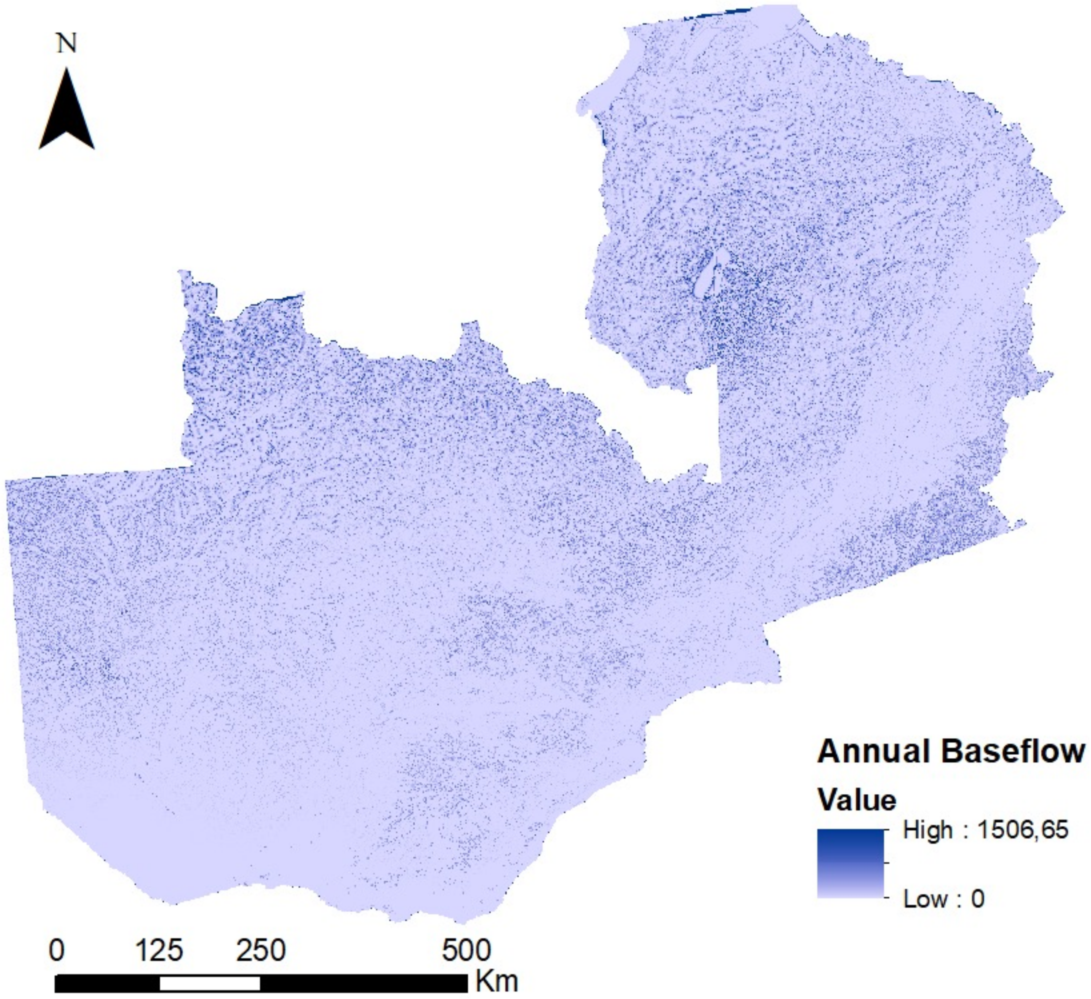
Annual average



SWY model outputs

- **Baseflow (mm)**

Annual average
Water reaching streams later (between rain events; during dry season; residence times of months to years)



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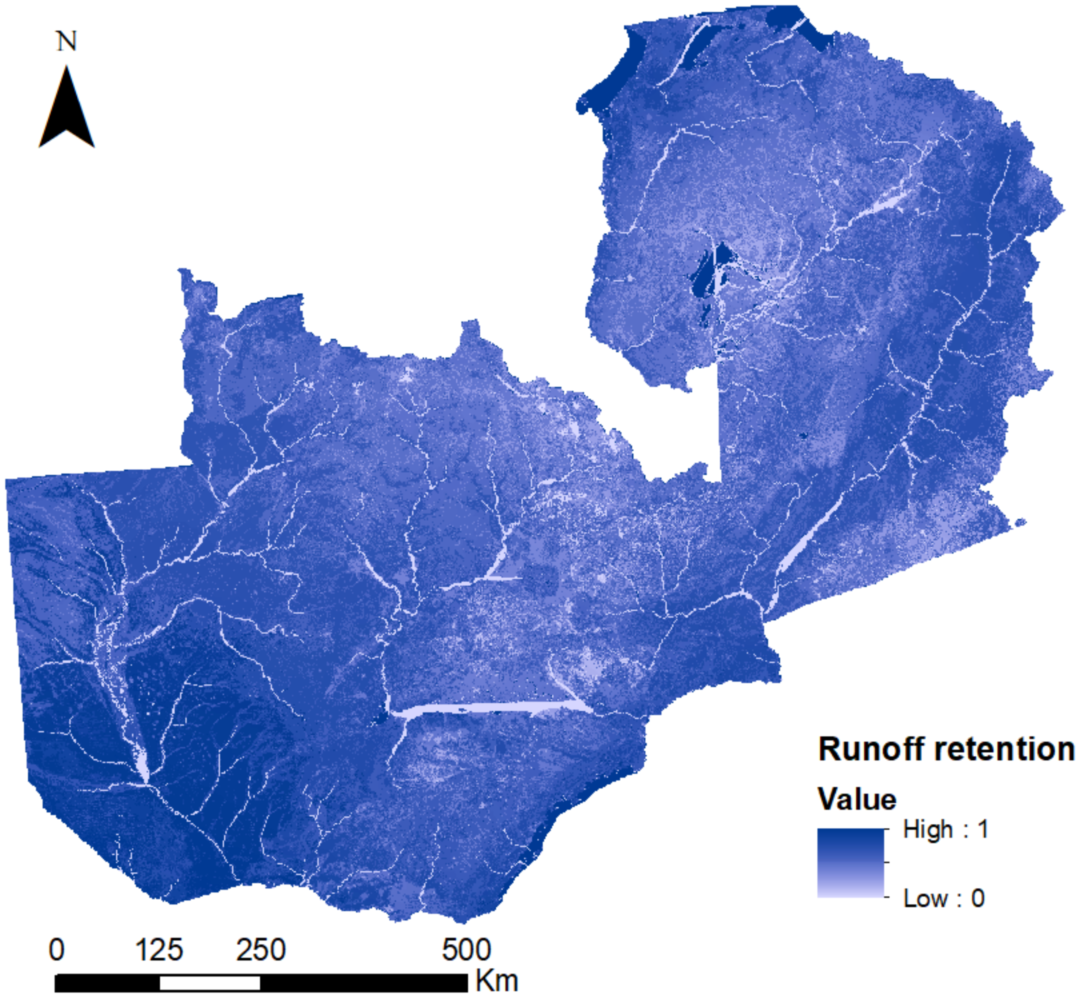
SWY model outputs

- **Runoff Retention**

1 – (QF/Precipitation)

Annual and monthly averages



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Potential applications

How does the water yield vary between dry years and wet years?

What is the impact of climate change on the water yield?

What is the forest/landscape restoration potential for water yield?

How to optimize the water yield use for production (food, electricity) with conservation?

Sediment Delivery Ratio Model

Key questions

- How is erosion as a natural process driven by topography, climate, vegetation, etc.?
- How does unsustainable land management increases erosion rates with impacts on food and water systems?
- How can erosion and sediment yield be controlled by human interventions on the landscape?

Decision contexts

Payments for watershed services programs

Global land use change impacts (agricultural expansion)

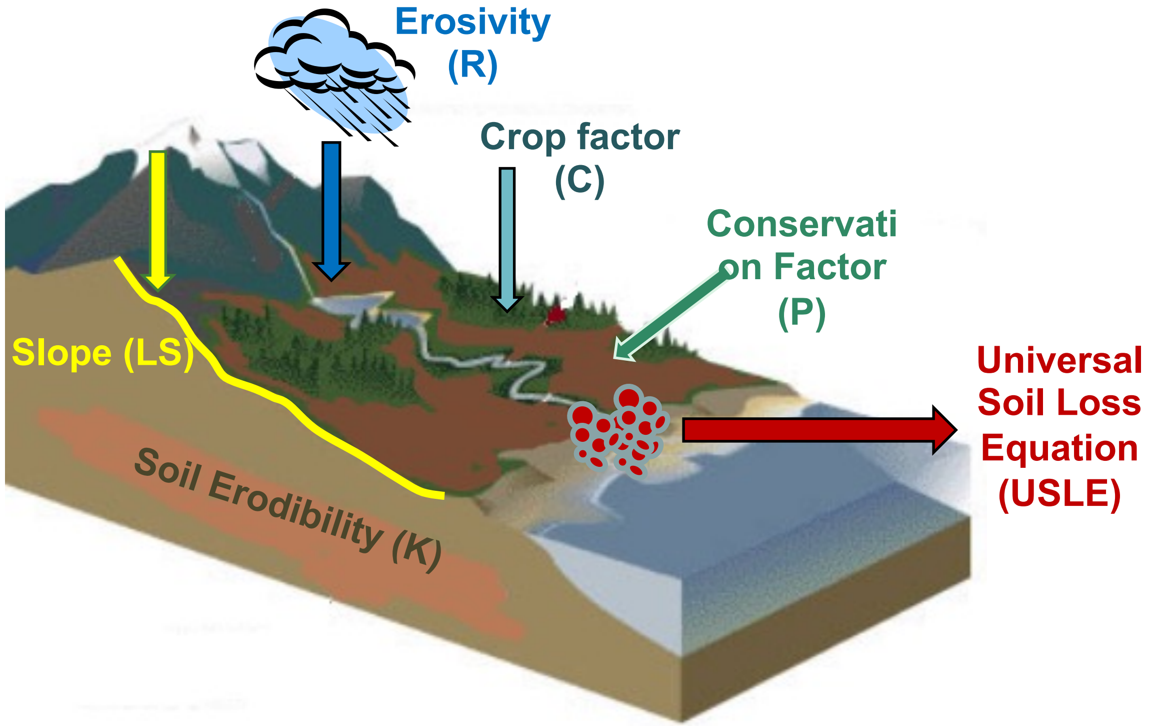
Impact assessment (infrastructure)

National accounting

InVEST Sediment Delivery Ratio: http://releases.naturalcapitalproject.org/invest-userguide/latest/sdr.html

SDR model

Modelled processes



Limitations

- Annual average values.
- Considers only one type of erosion (sheetwash/rill): no consideration of gully erosion, landslides, etc.
- Requires calibration data to increase confidence in quantitative exports (relative differences are captured better).
- Valuation methods are highly contextual (e.g. treatment type, local regulations).

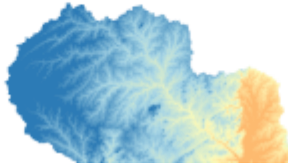
InVEST Sediment Delivery Ratio: http://releases.naturalcapitalproject.org/invest-userguide/latest/sdr.html

SDR model inputs

Climate
Rainfall erosivity

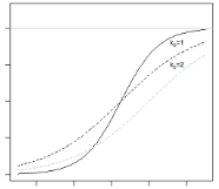
Watersheds
Main and sub-watersheds for point of interest

Soils
Soil erodibility



Topography
DEM, Threshold flow accumulation

Land Use/Land Cover
Crop factor and Practice factor



Calibration
Connectivity/SDR

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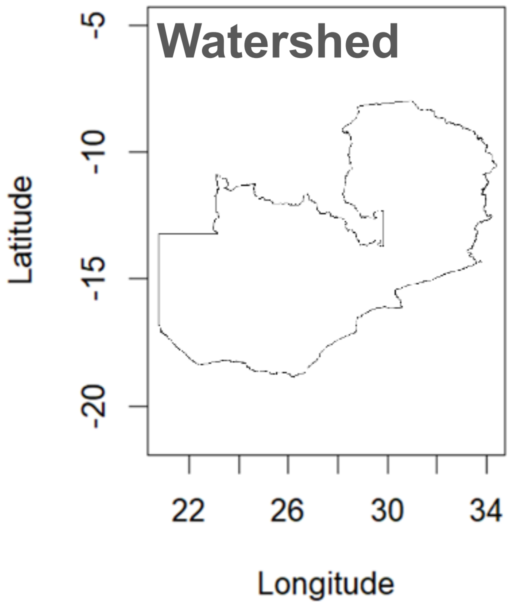
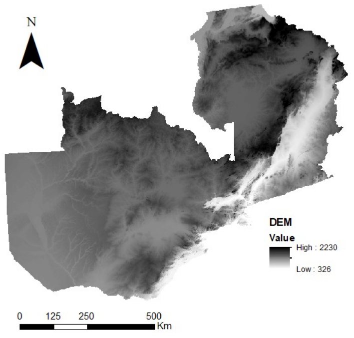
InVEST Sediment Delivery Ratio: http://releases.naturalcapitalproject.org/invest-userguide/latest/sdr.html

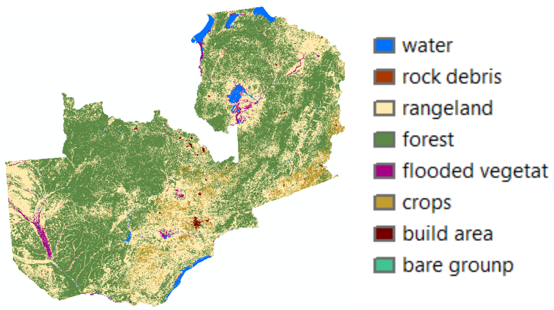
SDR model inputs



Topography

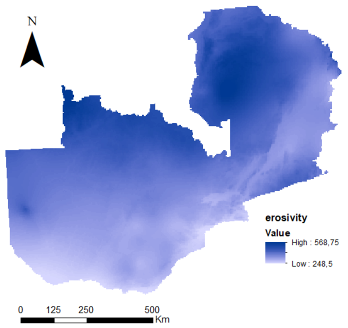


Land use / land cover

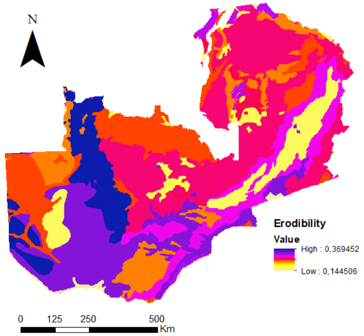


description	lucode	usle_c	usle_p
water	1	0	1
forest	2	0.025	1
flooded veget	4	0.2	1
crops	5	0.412	1
build area	7	0.99	1
bare ground	8	1	1
rock debris	10	0	1
rangeland	11	0.034	1

Rainfall erosivity



Soil erodibility



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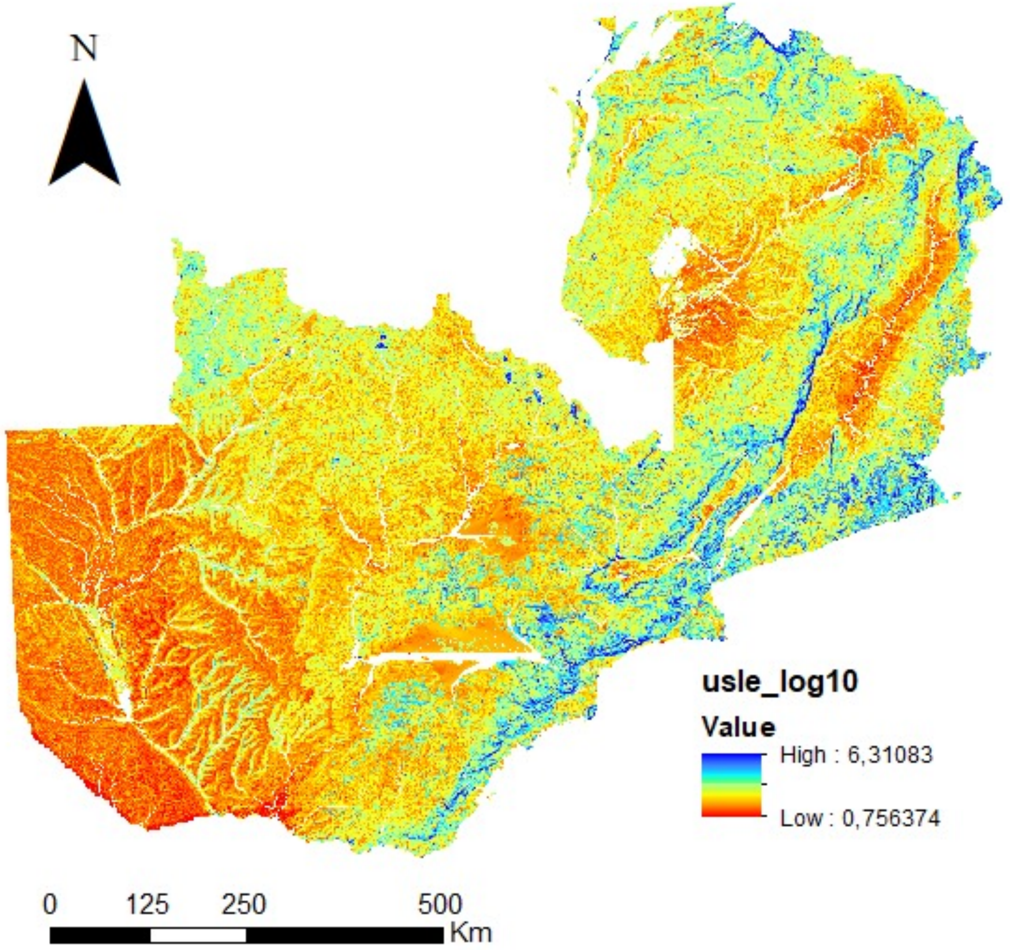
SDR model outputs

- **Potential soil loss (ton/yr)**

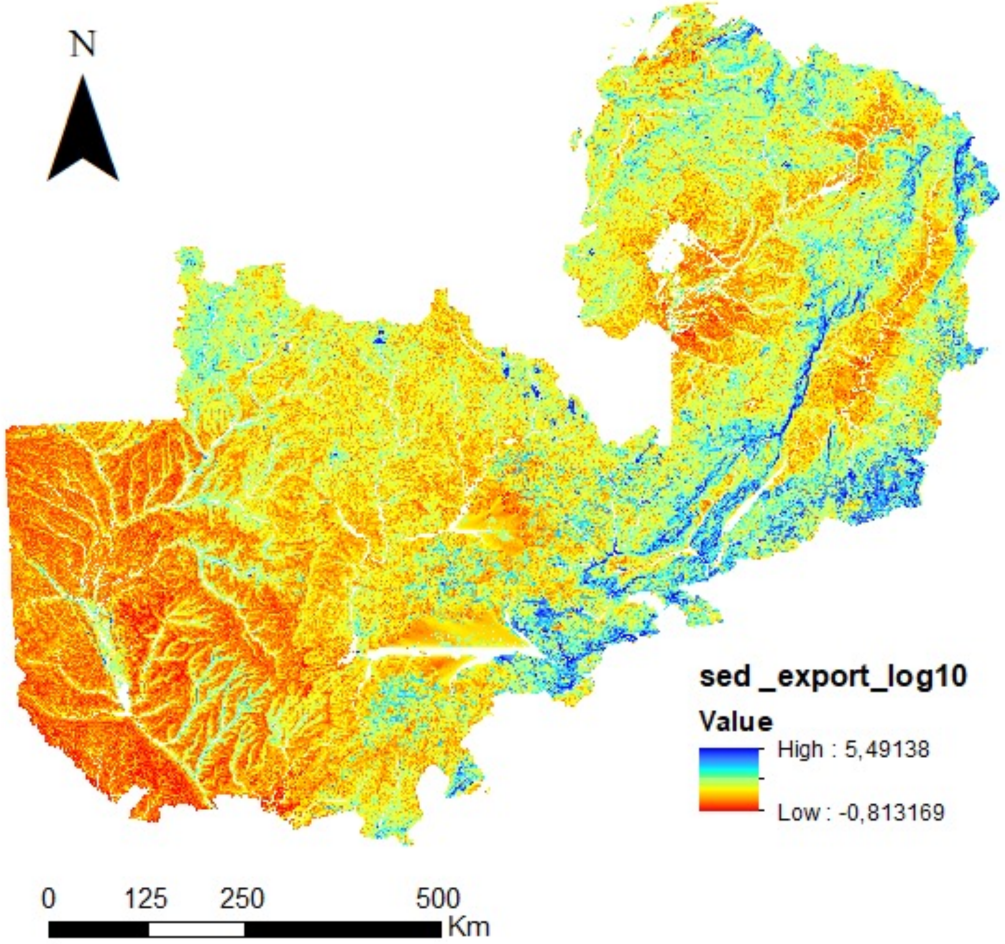
Results aggregated to watershed/sub-watersheds



SDR model outputs

- **Sediment export (ton/yr)**

Results aggregated to watershed/sub-watersheds

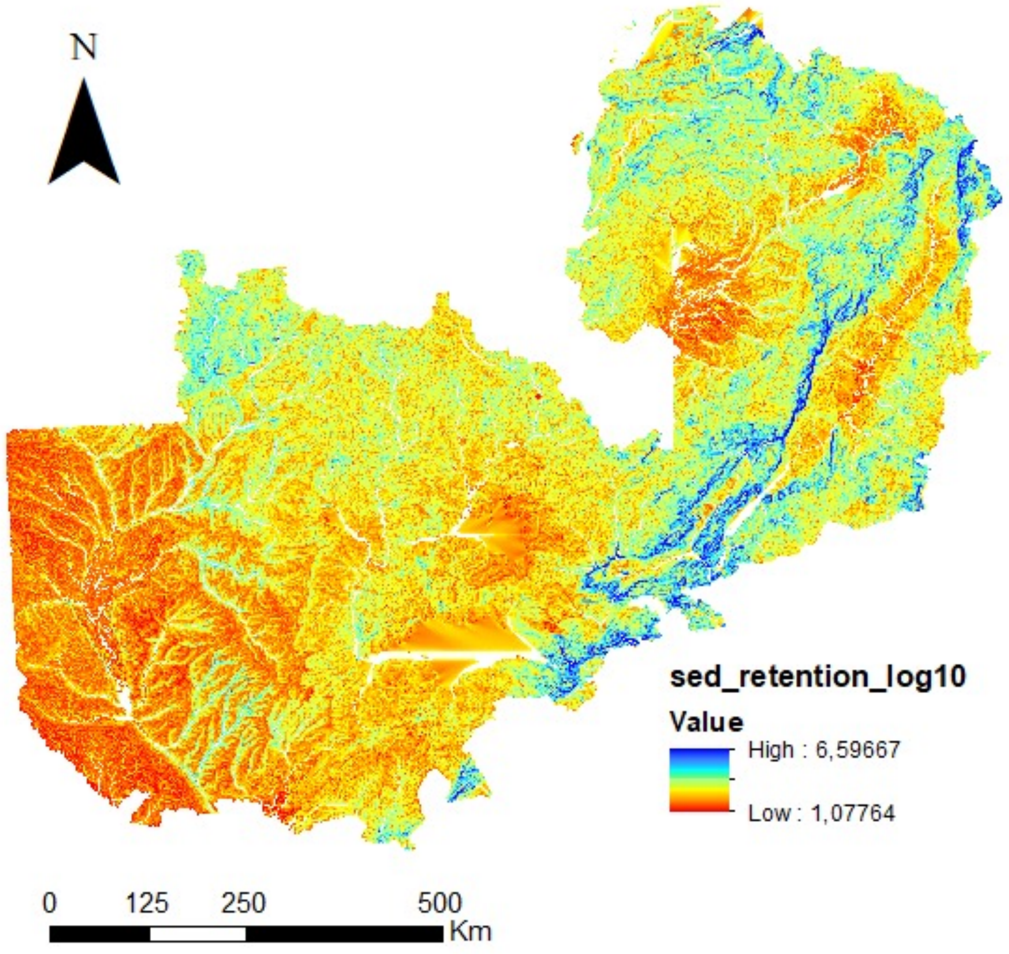


SDR model outputs

- **Sediment retention index**

Relative to bare ground

Results aggregated to watershed/sub-watersheds



Potential applications

Where are the most important sources of sediment production located?

How can different climate conditions determine erosion and sediment yield?

How human interventions and land planning can reduce erosion and sediment delivery?

What different alternative scenarios compare to decide future developmental pathways?

Nutrient Delivery Ratio Model

Key questions

- How much nutrient is produced on the landscape?
- Where is it produced?
- How does nutrient retention benefit people?

Decision contexts

Treatment plant

Drinking water

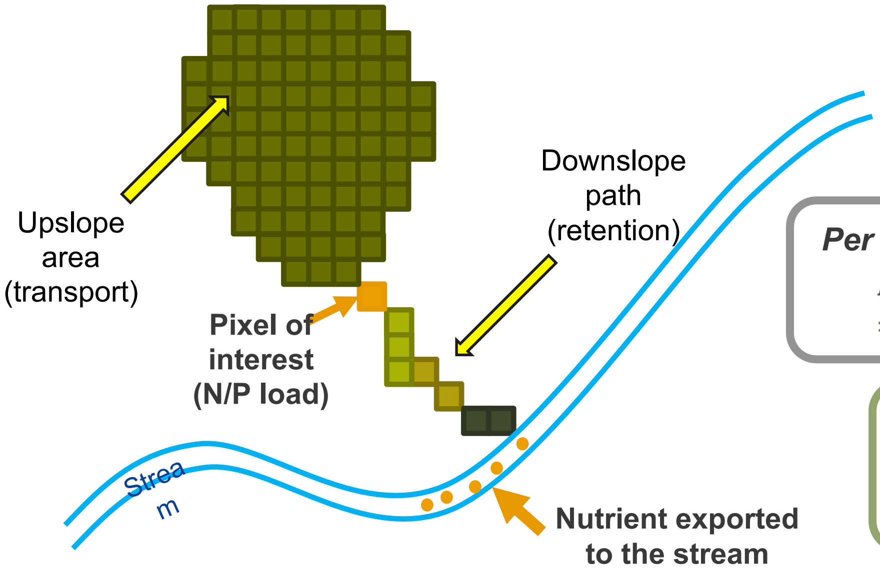
Pollution dilution

Stream health

InVEST Nutrient Delivery Ratio: http://releases.naturalcapitalproject.org/invest-userguide/latest/ndr.html

NDR model

Modelled processes



Per pixel:

$$NutrientExport = load \times NDR$$

Total export =

$$\sum_{pixel} NutrientExport$$

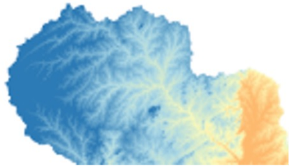
Limitations

- Non-point source.
- Simplified representation of nutrient transport, particularly subsurface.
- In-stream processes only, dam retention, etc. are not represented.
- Annual average values, not event-based.
- Requires calibration data to increase confidence in quantitative exports (relative differences are captured better).

InVEST Nutrient Delivery Ratio: http://releases.naturalcapitalproject.org/invest-userguide/latest/ndr.html

NDR model inputs

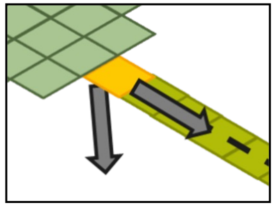
Climate
Precipitation
or quickflow



Topography
DEM, threshold flow
accumulation

Land Use/Land Cover
N/P load, efficiency,
retention length

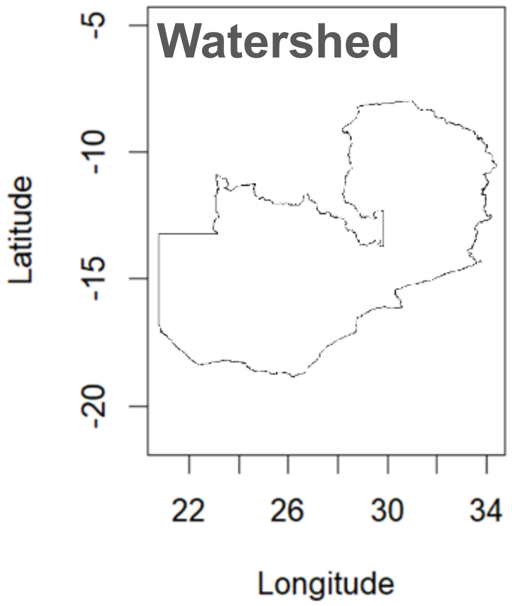
Watersheds
Serving point of
interest



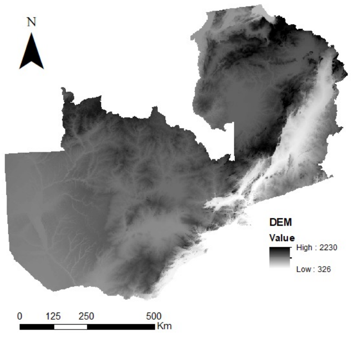
Optional
Information on
subsurface nutrients

InVEST Nutrient Delivery Ratio: http://releases.naturalcapitalproject.org/invest-userguide/latest/ndr.html

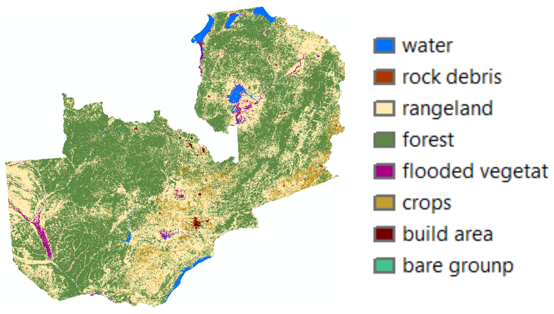
NDR model inputs



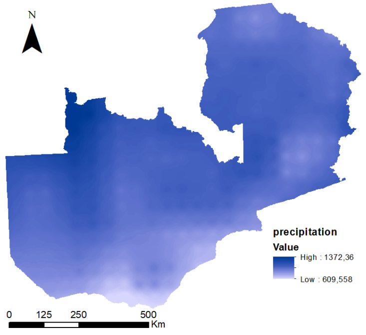
Topography



Land use / land cover

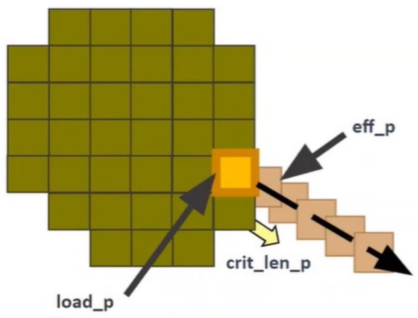


Annual precipitation



description	lucode	load_p	eff_p	crit_len_p
water	1	0	0.4	150
forest	2	2.1	0.67	150
flooded veget	4	1.5	0.65	150
crops	5	0.77	0.48	150
build area	7	0.6	0.26	150
bare ground	8	0.79	0.26	150
rock debris	10	0	0.3	150
rangeland	11	0.93	0.6	150

Biophysical table



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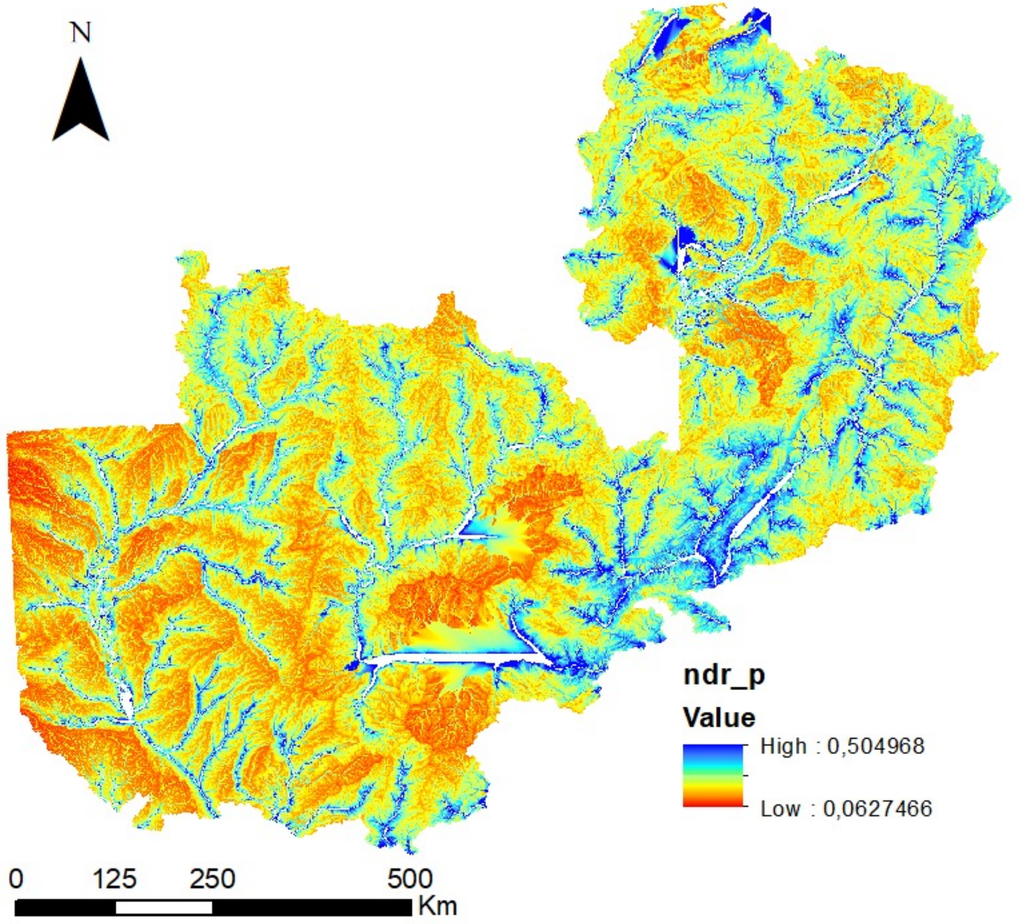
NDR model outputs

- **Nutrient discharge rate**
Shows the pattern of nutrient sources

Results aggregated to watershed/sub-watersheds

High-export areas could be targets for **restoration**.
Low-export areas could be targets for **conservation**.



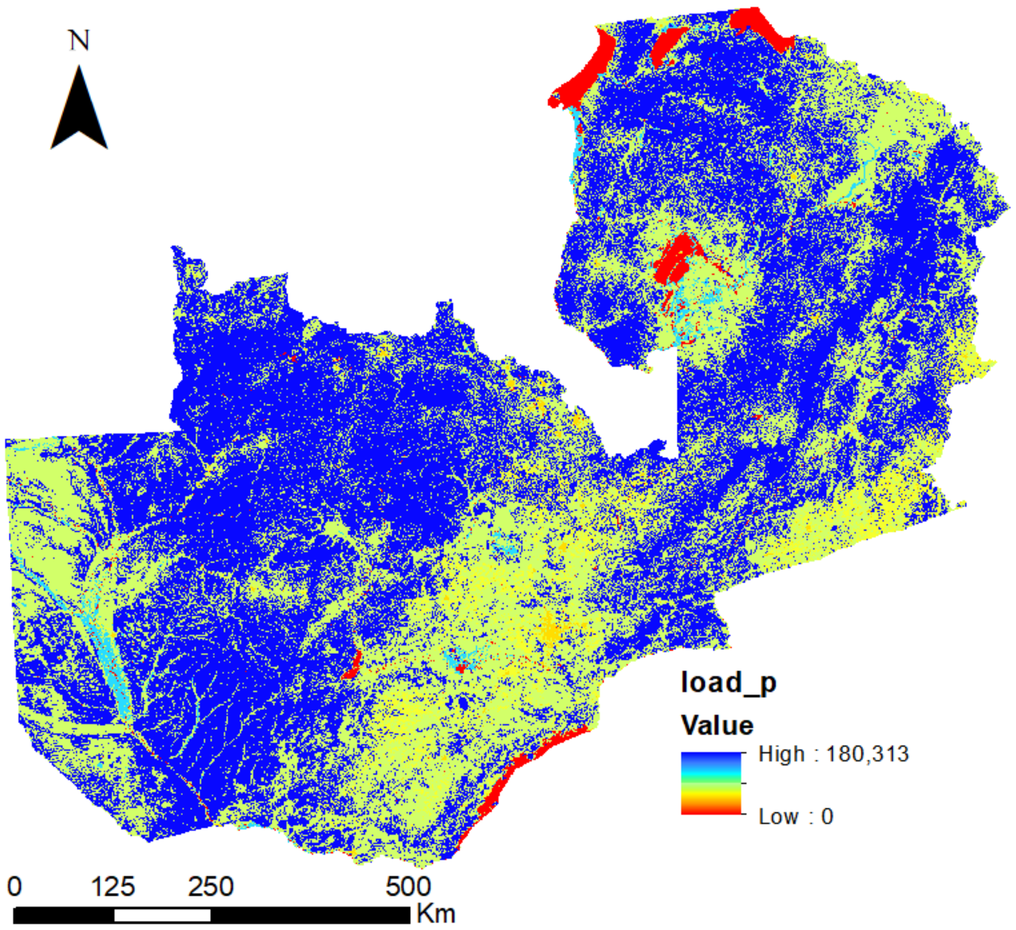
NDR model outputs

- **Load (kg/yr)**

Shows the pattern of nutrient sources

Results aggregated to watershed/sub-watersheds

High-export areas could be targets for **restoration**.
Low-export areas could be targets for **conservation**.

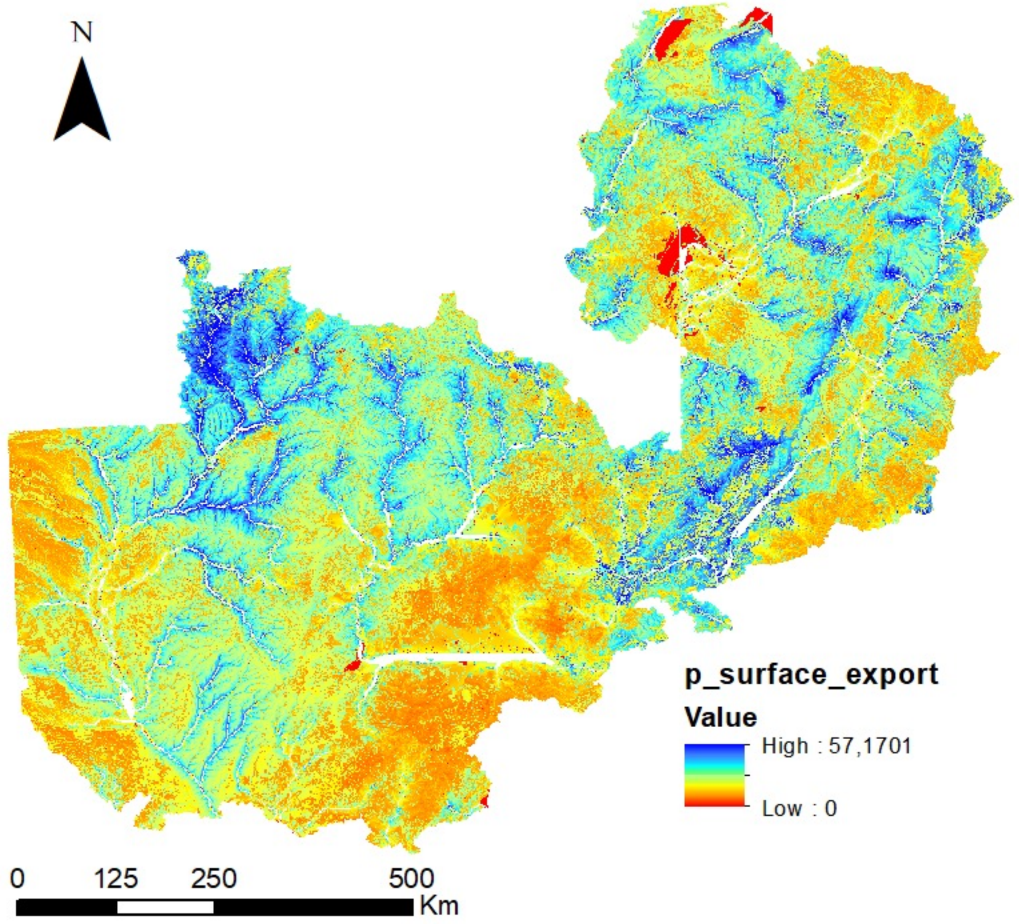


NDR model outputs

- **Nutrient export per pixel (kg/yr)**

Relative to bare ground

Results aggregated to watershed/sub-watersheds



Potential applications

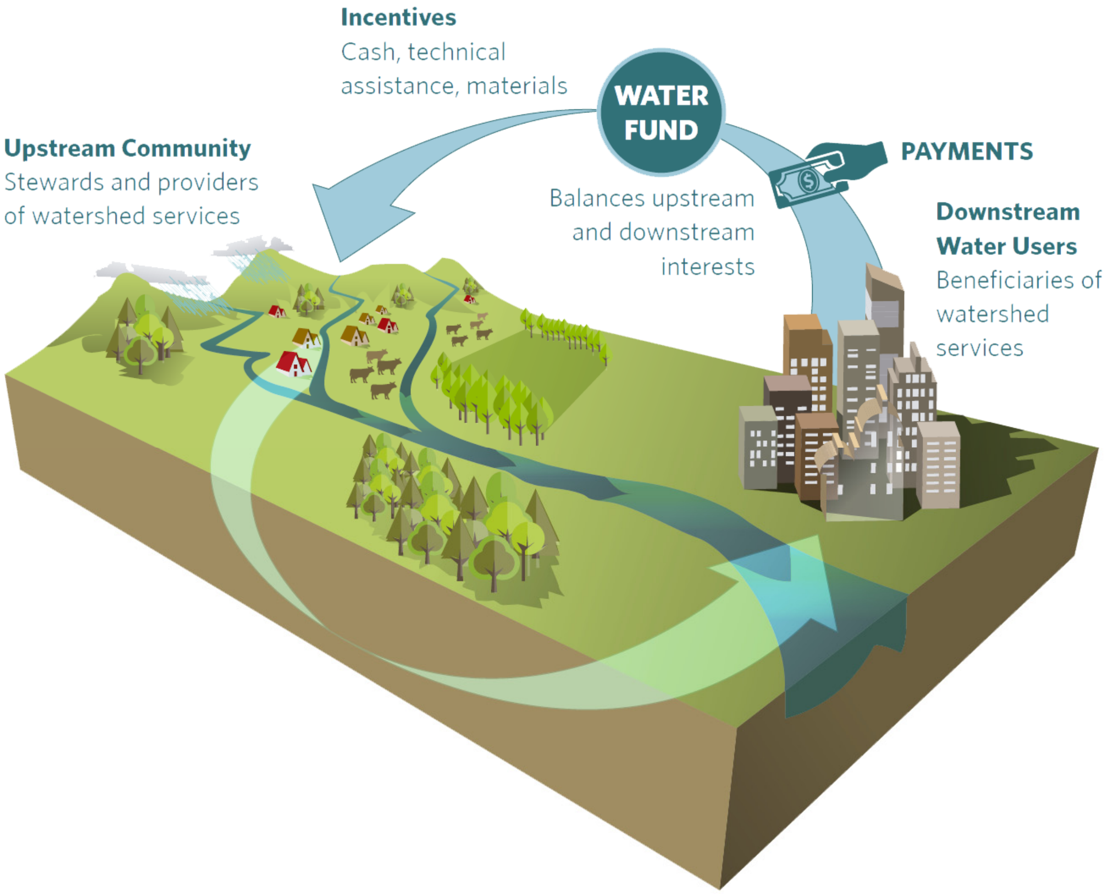
Where are the most important sources of nutrient delivery located?

How can different climate conditions and seasonality determine nutrient delivery?

How human interventions and land planning can reduce nutrient delivery?

What different alternative scenarios compare to decide future developmental pathways?

Overview of policy applications



- LAND USE PLANNING
- DEVELOPMENT PLANS (NATIONAL, LOCAL)
- CLIMATE CHANGE ADAPTATION PLANS
- ECONOMIC AND ENERGY TRANSITIONS
- PAYMENT FOR ECOSYSTEM SERVICES
- POVERTY ALLEVIATION AND DEVELOPMENT

Thank you

Questions?

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BELA Biodiversity, Ecosystems, & Landscape Assessment

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