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Global Food Security

journal homepage: www.elsevier.com/locate/gfs



Role and management of soil biodiversity for food security and nutrition;
where do we stand?



V. El Mujtar^{a,*}, N. Muñoz^b, B. Prack Mc Cormick^{c,d}, M. Pulleman^{e,f}, P. Tittonell^{a,d}

Goals

- To provide an overview of the relations between soil biodiversity, agricultural management and food production
- To provide scientific evidences of the potential of soil biodiversity management to improves food security and nutrition



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where do we stand?

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**SOIL
BIODIVERSITY**



FOOD SECURITY PILLARS

AVAILABILITY

ACCESS

NUTRITION &
SAFETY

STABILITY

Systematic literature search



WEB OF SCIENCE™
Scopus®

Search strategy 1
[56,631]^a

Search strategy 2
[62]^a

Search strategy 3
[173]^a

Search strategy 4
[232]^a

Classified according to scientific research topics

*Publication date
*Terms for SBD
*Geographic region

*Scale of SBD research
*Coverage of SBD research topics

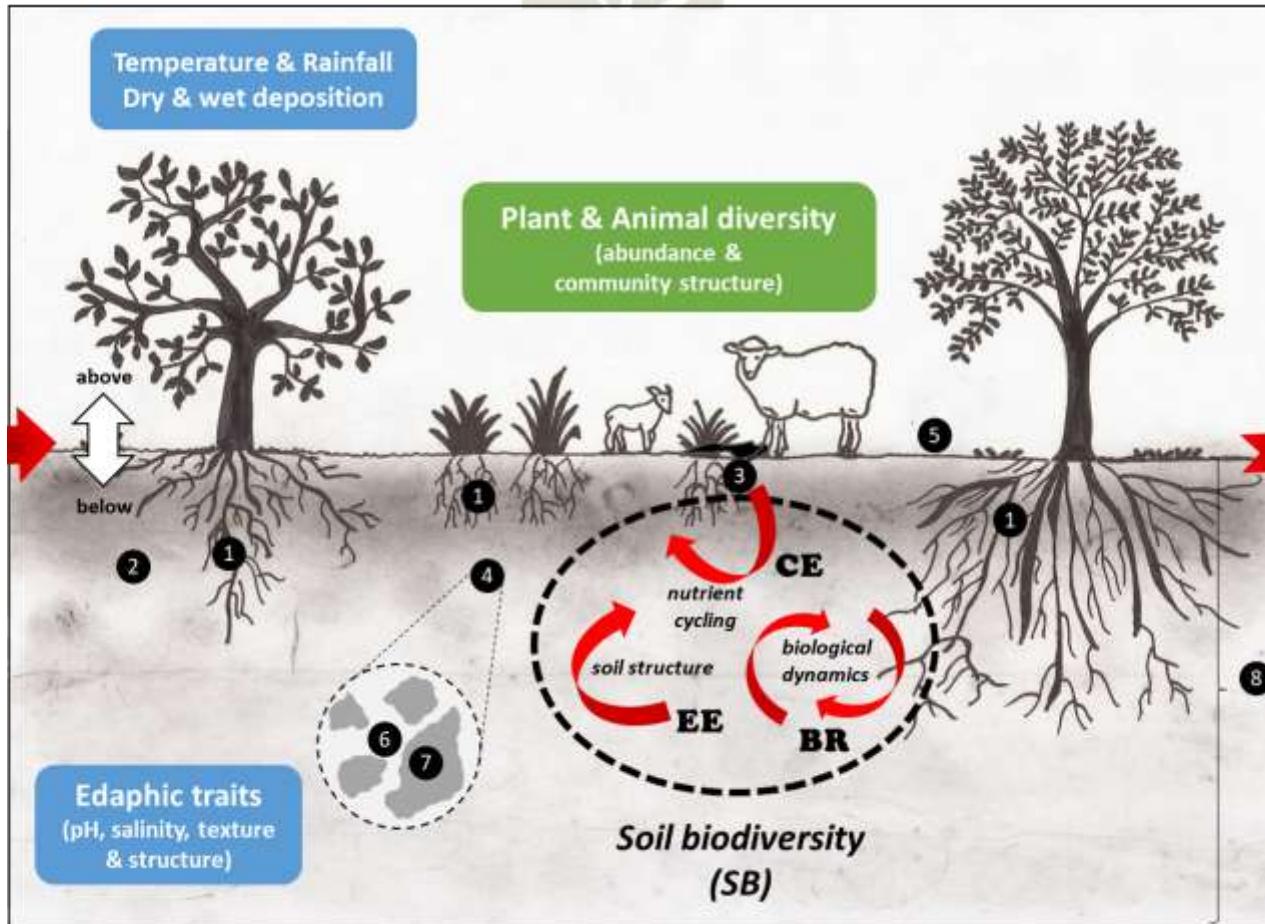
*Major soil organisms and crops studied

*Major scientific topic
*Direct role of soil biota and impact on productivity
*Soil organisms studied

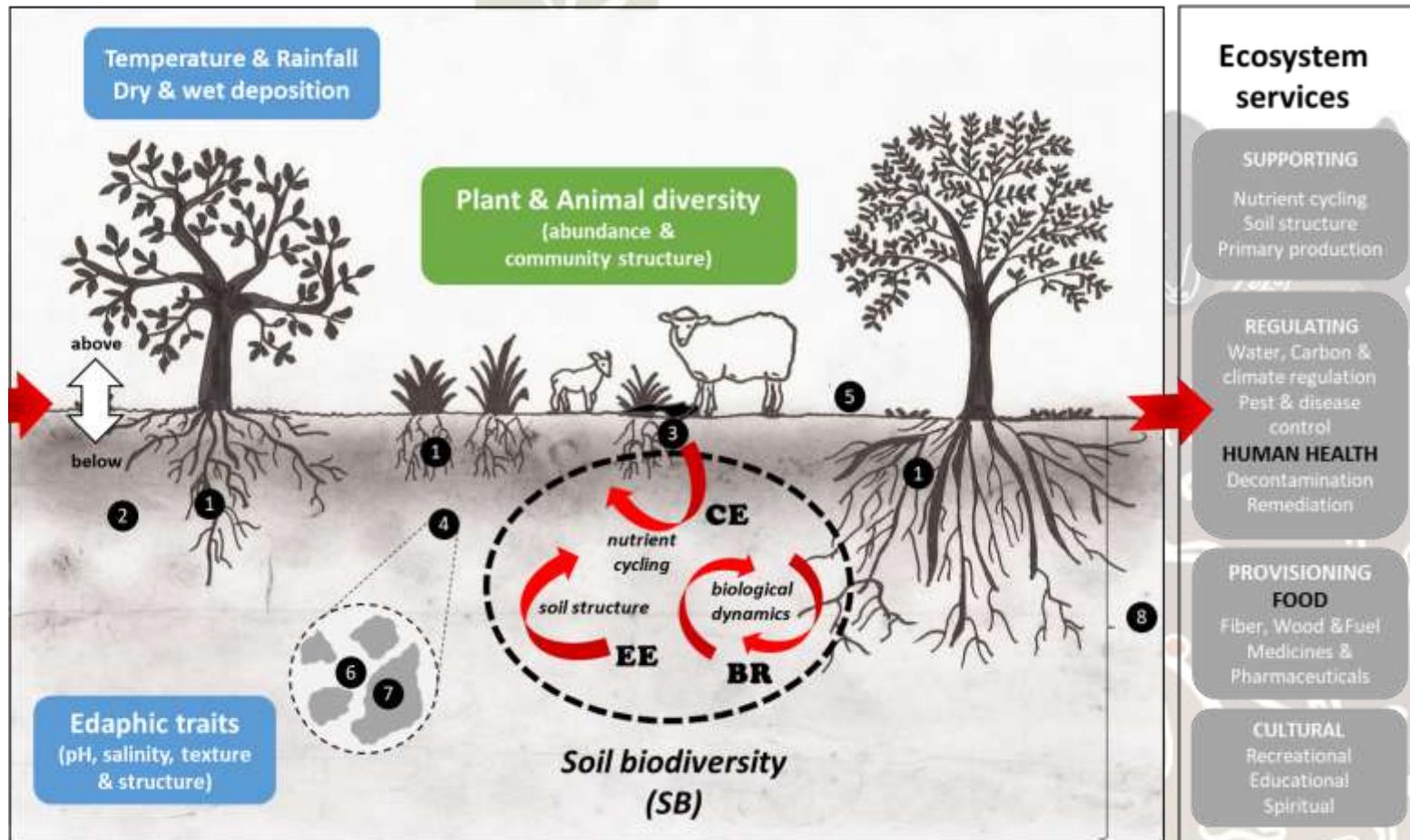
Trends on Soil Biodiversity research
Land use and agricultural impacts on soil biodiversity
Soil Biodiversity Management and Food Security



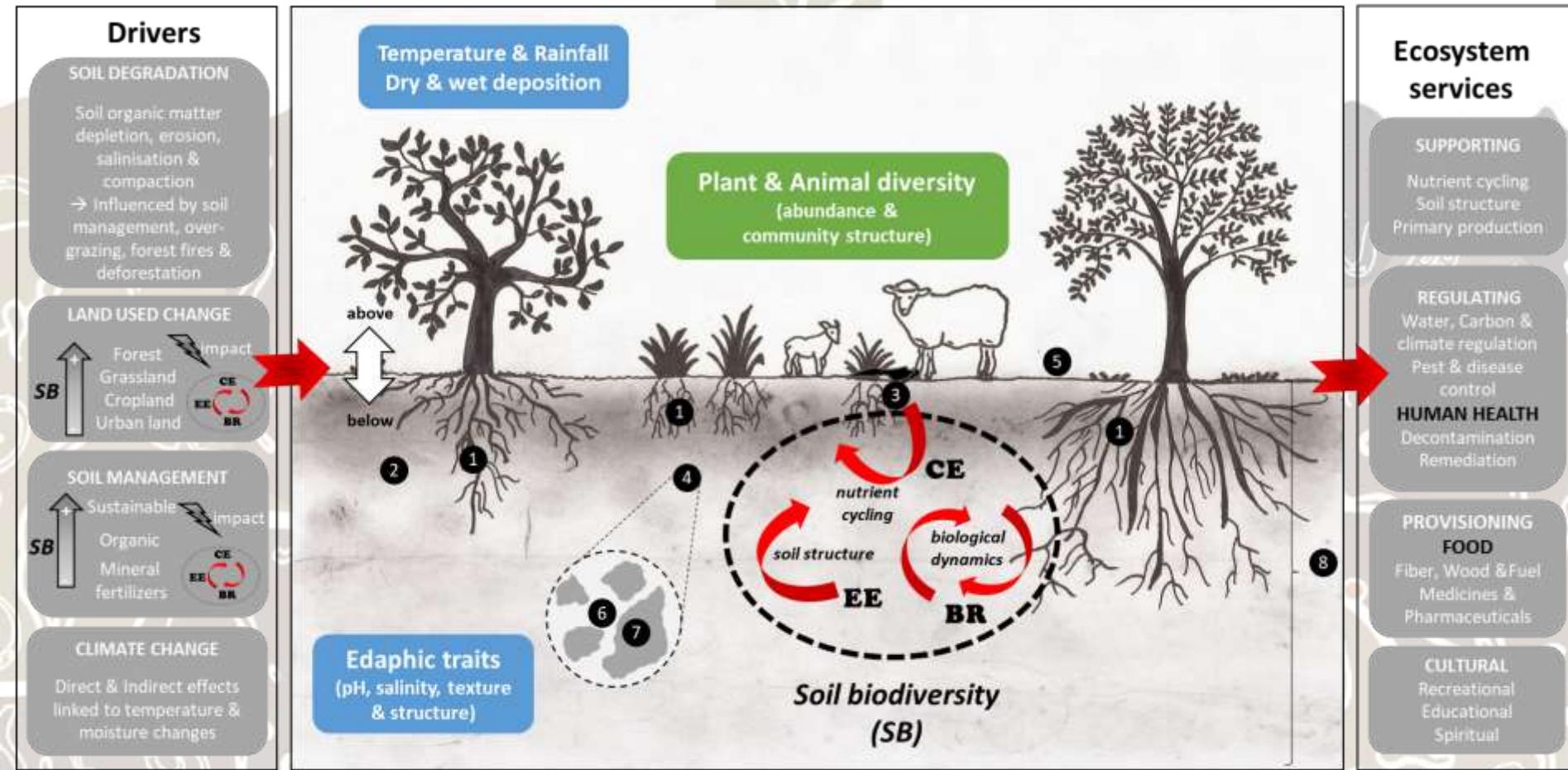
Soil biodiversity



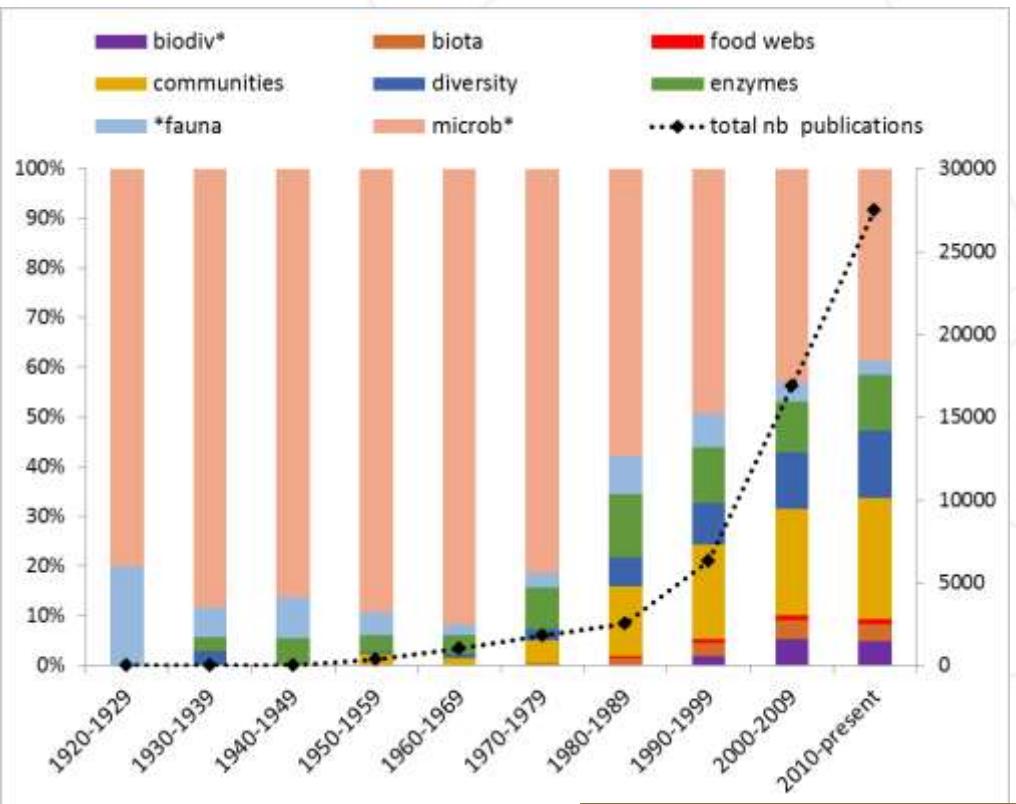
Soil biodiversity



Soil biodiversity

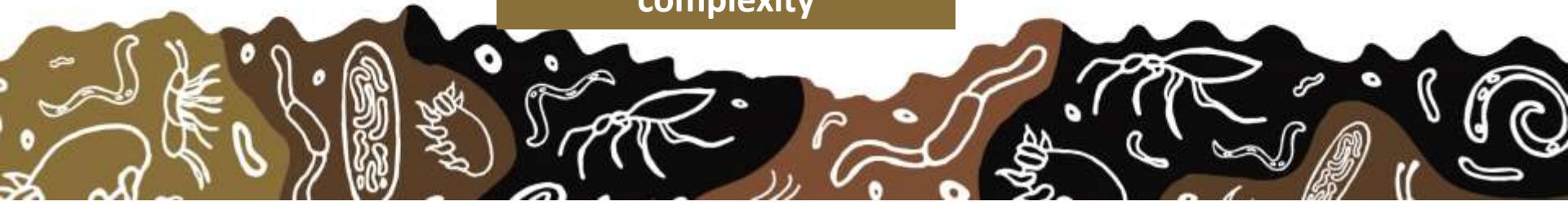


Trends on soil biodiversity research

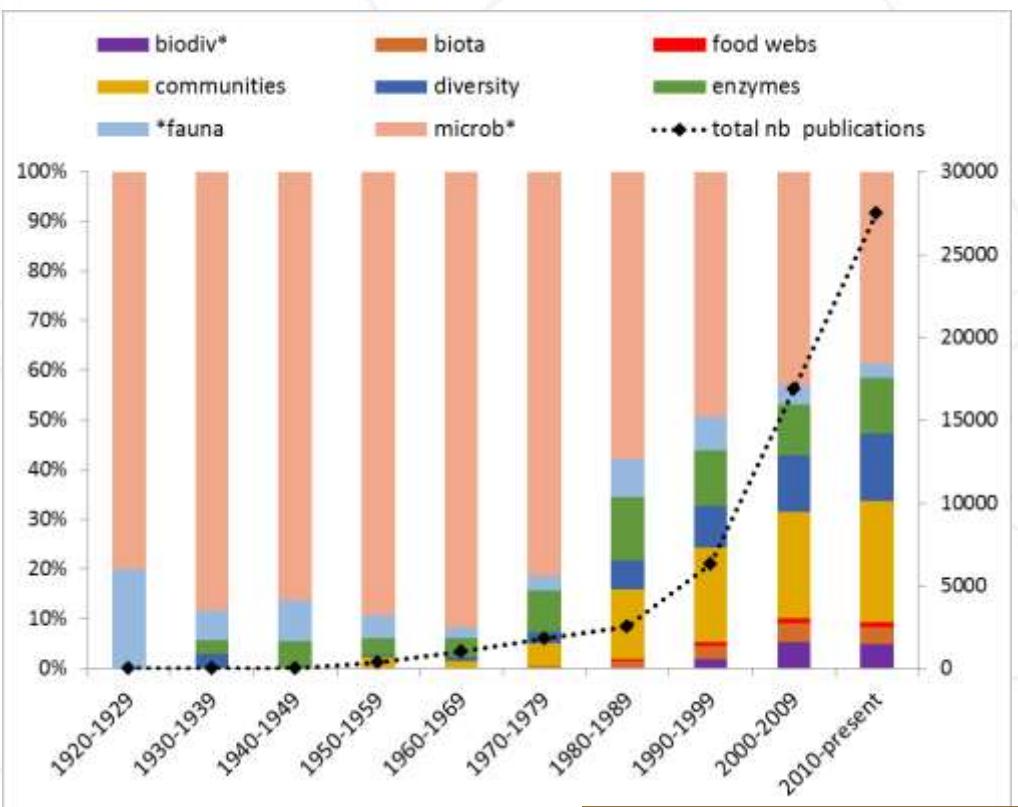


**Soil biodiversity (SB)
research over time**

**Growing understanding
and appreciation of soil
biodiversity and its
complexity**



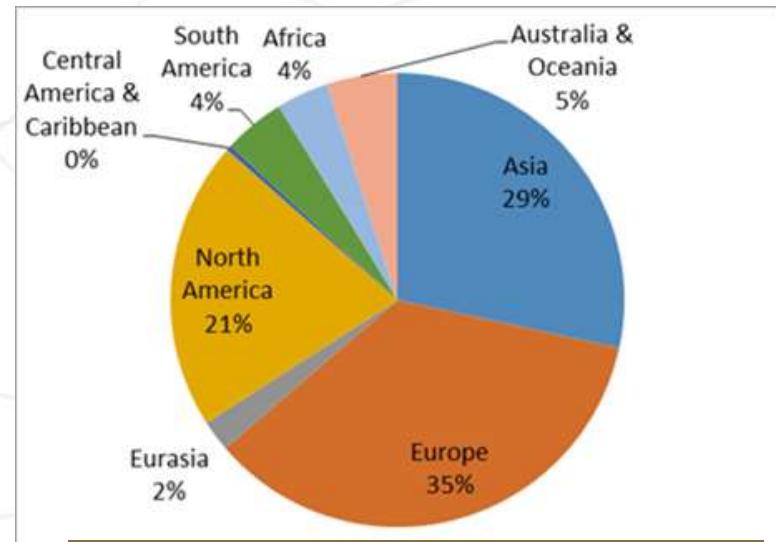
Trends on soil biodiversity research



**Soil biodiversity (SB)
research over time**

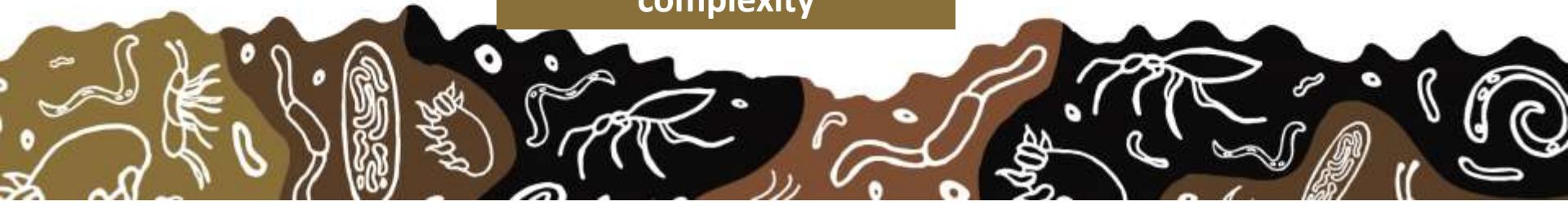
**Growing understanding
and appreciation of soil
biodiversity and its
complexity**

Geographic distribution of SB research

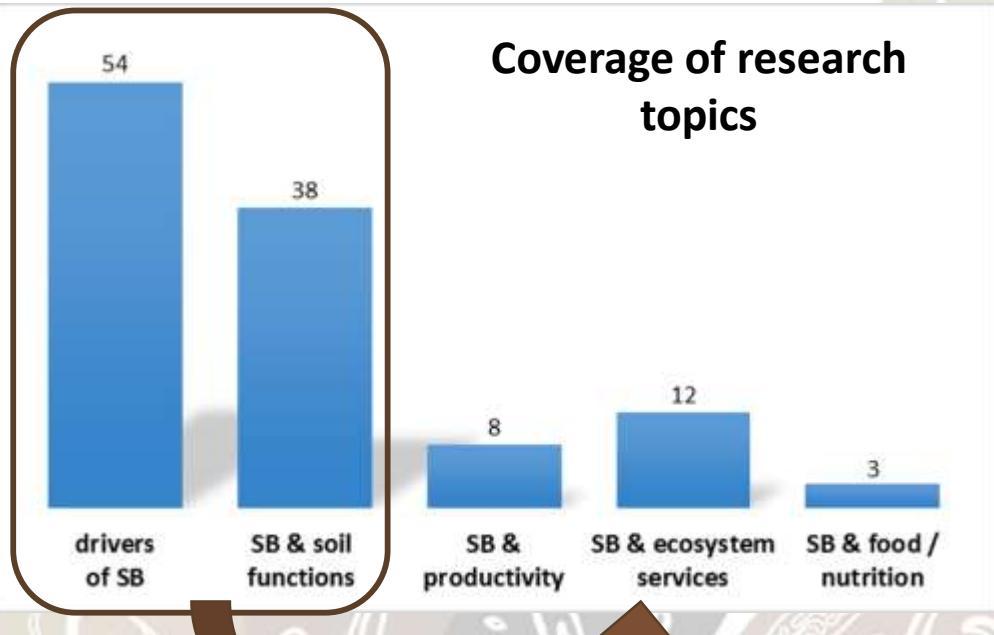


**87% of soil biodiversity research
is from Northern hemisphere**

**→ Research gap for Southern
hemisphere**



Trends on soil biodiversity research



Potential of soil biodiversity management to improves soil productivity, ecosystem services and food security and nutrition

Trends on soil biodiversity research

54

38

drivers
of SB

SB & soil
functions

Coverage of research topics

8

12

SB &
food /
nutrition

SB &
productivity

SB &
ecosystem
services

117

95

bacteria

fungi

yeast

others

Soil organisms & plant productivity

Potential of soil biodiversity
management to improves
soil productivity, ecosystem
services and food security
and nutrition

Chemical engineers (CE)
Soil processes related to CE

C & nutrient cycling
Soil organic matter dynamics
Plant-soil biota interactions

Trends on soil biodiversity research

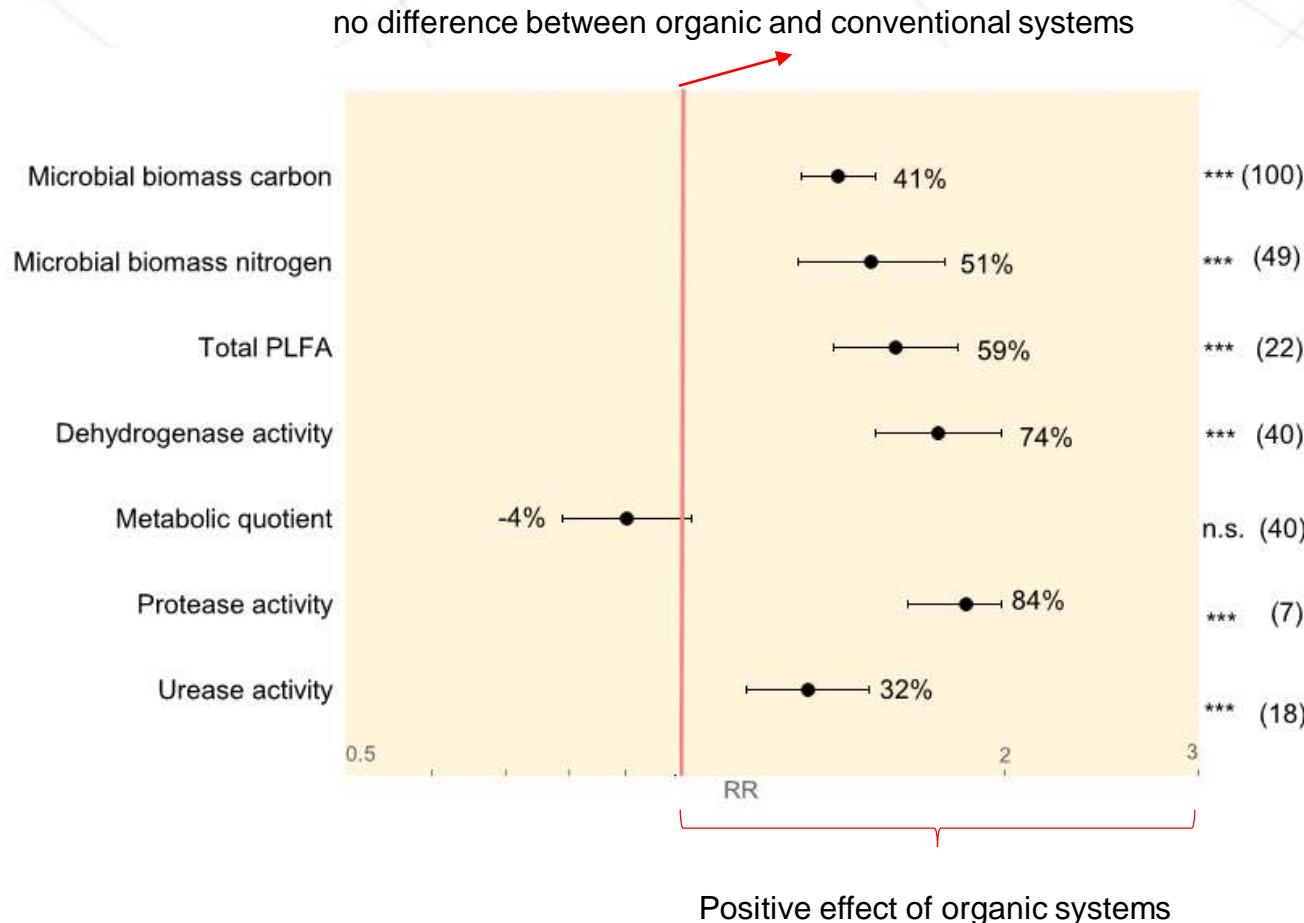
Functional group	Forest → Grassland	Grassland → Cropland	Cropland → Urban land
Chemical engineers	↘ ↘ fungi, ↗ bacteria	↘ (but some local ↗)	↘
Biological regulators	= / ↗ ↗ nematodes ↘ microarthropods	↘ Plant-feeding -> bacteria-feeding nematodes	↘
Ecosystem engineers	↗ anecic -> endogeic earthworms	↘ / 0 ↘ anecic earthworms	↘

Ecosystem service	Forest → Grassland	Grassland → Cropland	Cropland → Urban land	Affected soil functions
Soil fertility and nutrient cycling	=/↘	↘	↘	Reduced decomposition of soil organic matter Reduced biological control
Regulation of carbon flux and climate control	↘	↘	↘	Reduced decomposition and mixing of soil organic matter
Regulation of the water cycle	-	↘	↘	Reduced burrowing activity
Decontamination and bioremediation	-	↘	↘	Impaired self-regulation of ecosystems
Pest control	-	↘	↘	Reduced biological control

Diversity & diversity-mediated soil processes are **negatively** affected by land use change and intensive agriculture

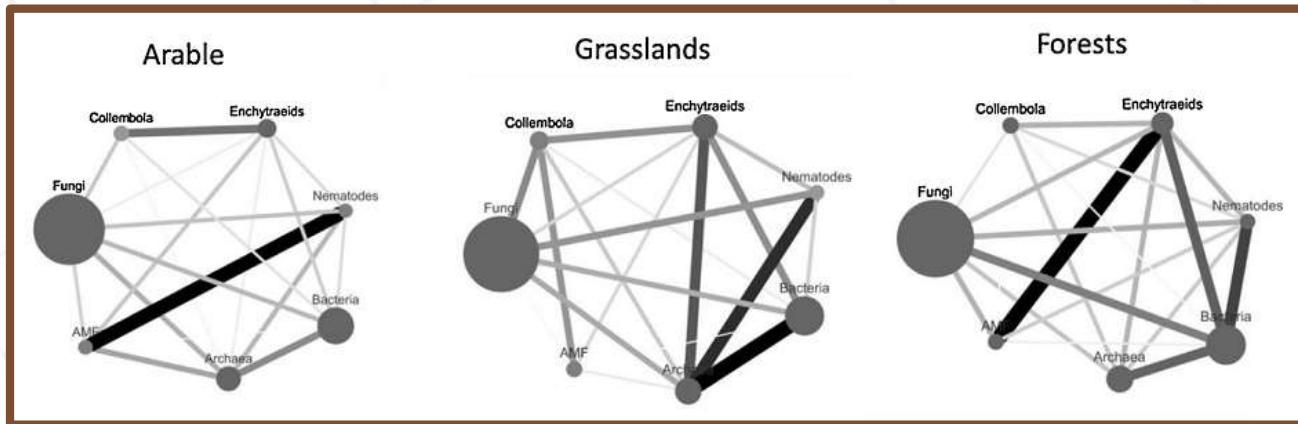


Trends on soil biodiversity research

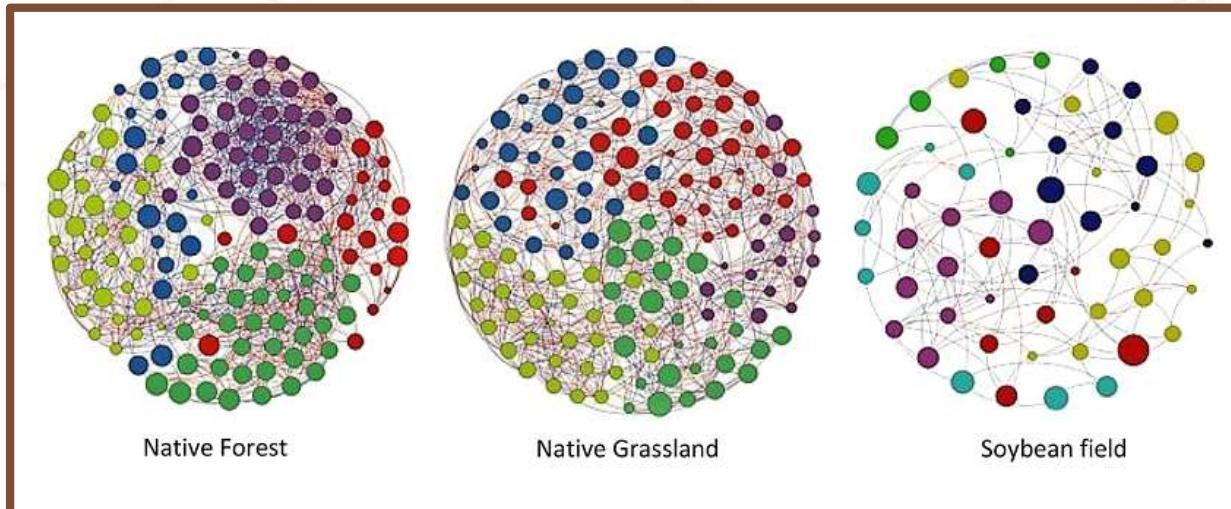


Diversity & diversity-mediated soil processes are **positively** affected by organic or agro-ecological farming

Trends on soil biodiversity research



Network interactions could be **more important** than richness and abundance

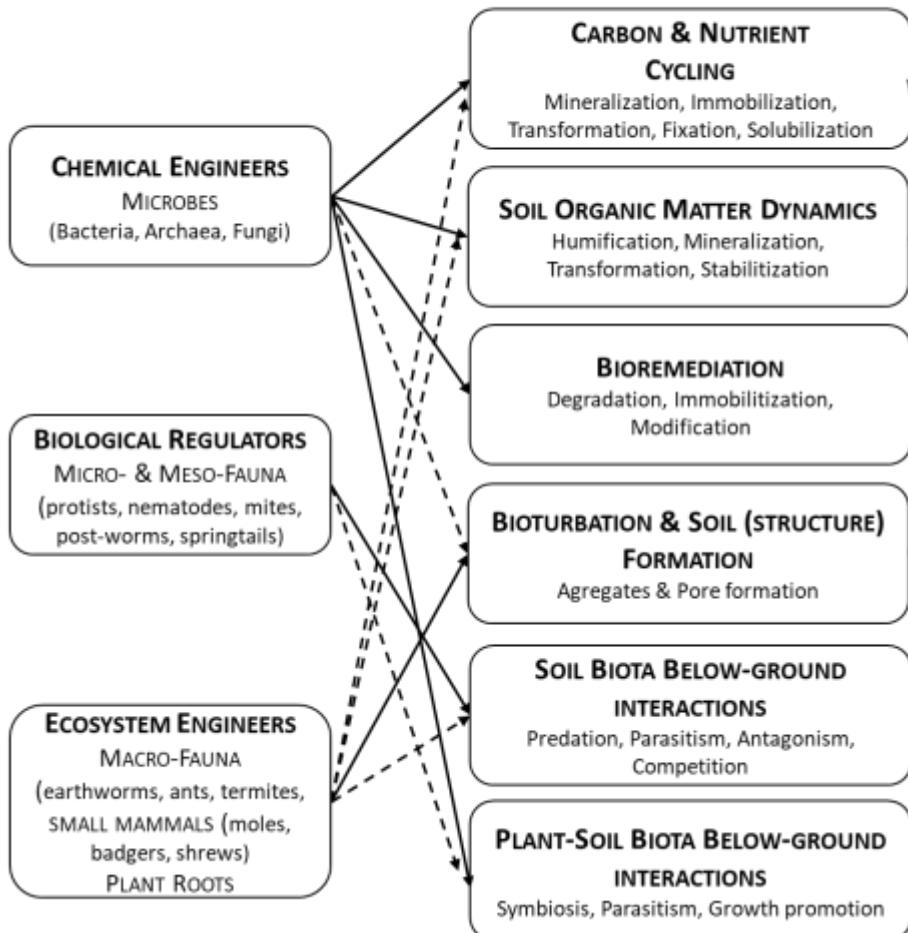


Soil biodiversity and food security

Direct and indirect effects

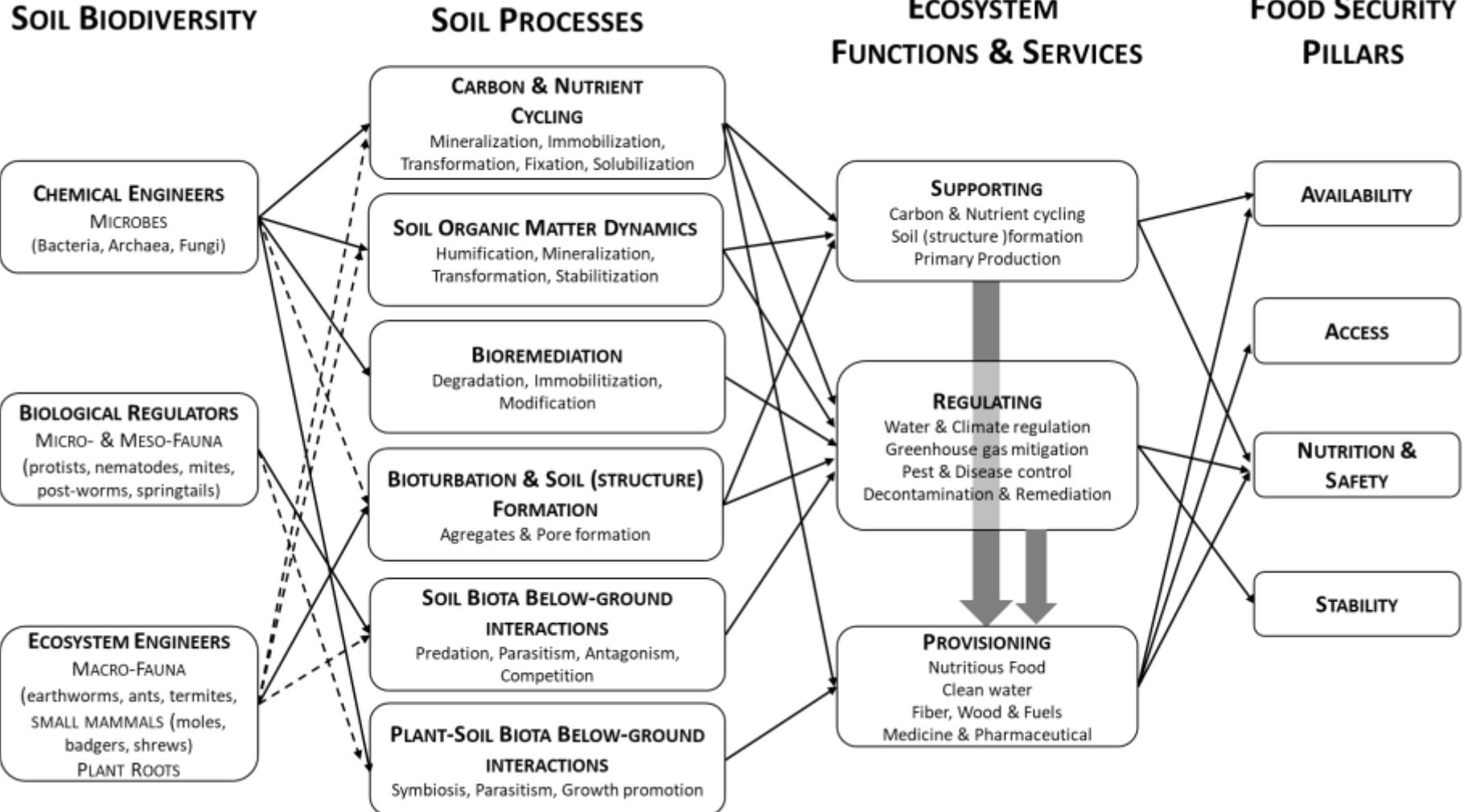
SOIL BIODIVERSITY

SOIL PROCESSES

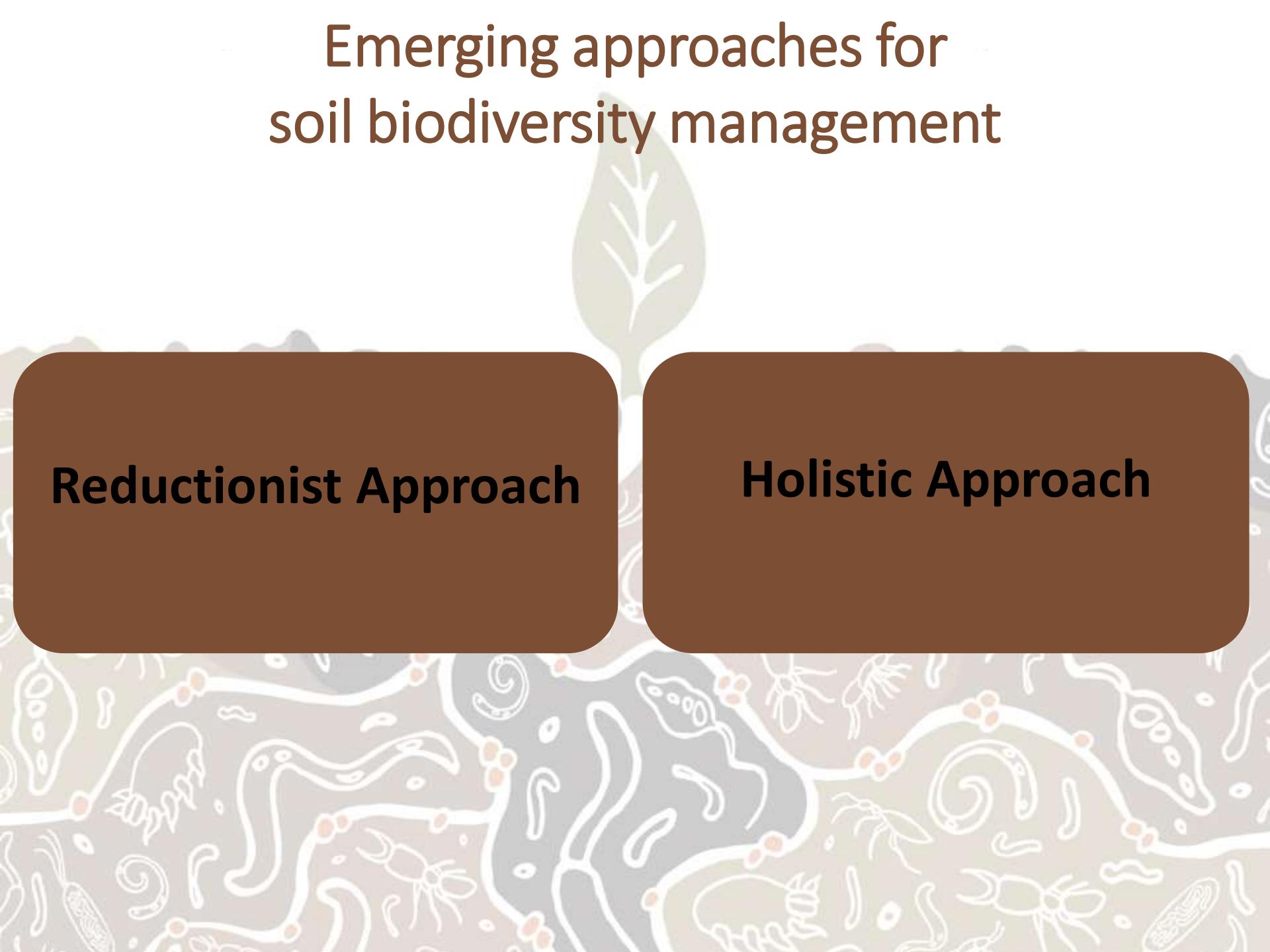


Soil biodiversity and food security

Direct and indirect effects



Emerging approaches for soil biodiversity management

A light gray background featuring a dense, intricate pattern of soil organisms in white and light orange. The pattern includes various microorganisms, nematodes, small arthropods, and root structures, creating a complex web of life.

Reductionist Approach

Holistic Approach

Soil biodiversity management by Reductionist Approach

SOIL BIODIVERSITY

CHEMICAL ENGINEERS
MICROBES
(Bacteria, Archaea, Fungi)

BIOLOGICAL REGULATORS
MICRO- & MESO-FAUNA
(protists, nematodes, mites, post-worms, springtails)

ECOSYSTEM ENGINEERS
MACRO-FAUNA
(earthworms, ants, termites,
SMALL MAMMALS (moles,
badgers, shrews)
PLANT ROOTS

SOIL PROCESSES

CARBON & NUTRIENT CYCLING

Mineralization, Immobilization, Transformation, Fixation, Solubilization

SOIL ORGANIC MATTER DYNAMICS

Humification, Mineralization, Transformation, Stabilization

BIOREMEDIATION

Degradation, Immobilization, Modification

BIOTURBATION & SOIL (STRUCTURE) FORMATION

Aggregates & Pore formation

SOIL BIOTA BELOW-GROUND INTERACTIONS

Predation, Parasitism, Antagonism, Competition

PLANT-SOIL BIOTA BELOW-GROUND INTERACTIONS

Symbiosis, Parasitism, Growth promotion

ECOSYSTEM FUNCTIONS & SERVICES

SUPPORTING

Carbon & Nutrient cycling
Soil (structure) formation
Primary Production

REGULATING

Water & Climate regulation
Greenhouse gas mitigation
Pest & Disease control
Decontamination & Remediation

PROVISIONING

Nutritious Food
Clean water
Fiber, Wood & Fuels
Medicine & Pharmaceutical

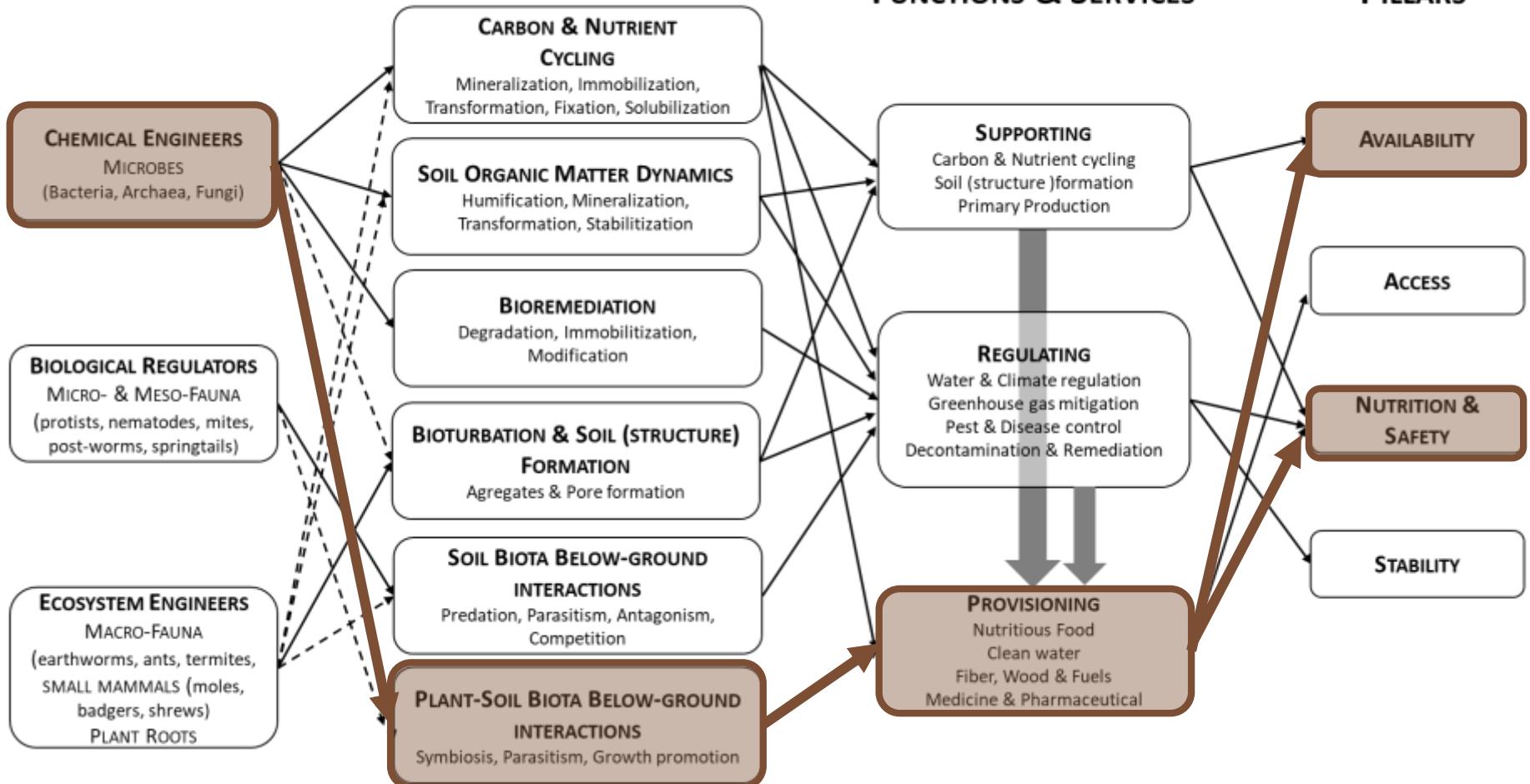
FOOD SECURITY PILLARS

AVAILABILITY

ACCESS

NUTRITION & SAFETY

STABILITY



Soil biodiversity management by Holistic Approach

SOIL BIODIVERSITY

CHEMICAL ENGINEERS
MICROBES
(Bacteria, Archaea, Fungi)

BIOLOGICAL REGULATORS
MICRO- & MESO-FAUNA
(protists, nematodes, mites, post-worms, springtails)

ECOSYSTEM ENGINEERS
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Clean water
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Medicine & Pharmaceutical

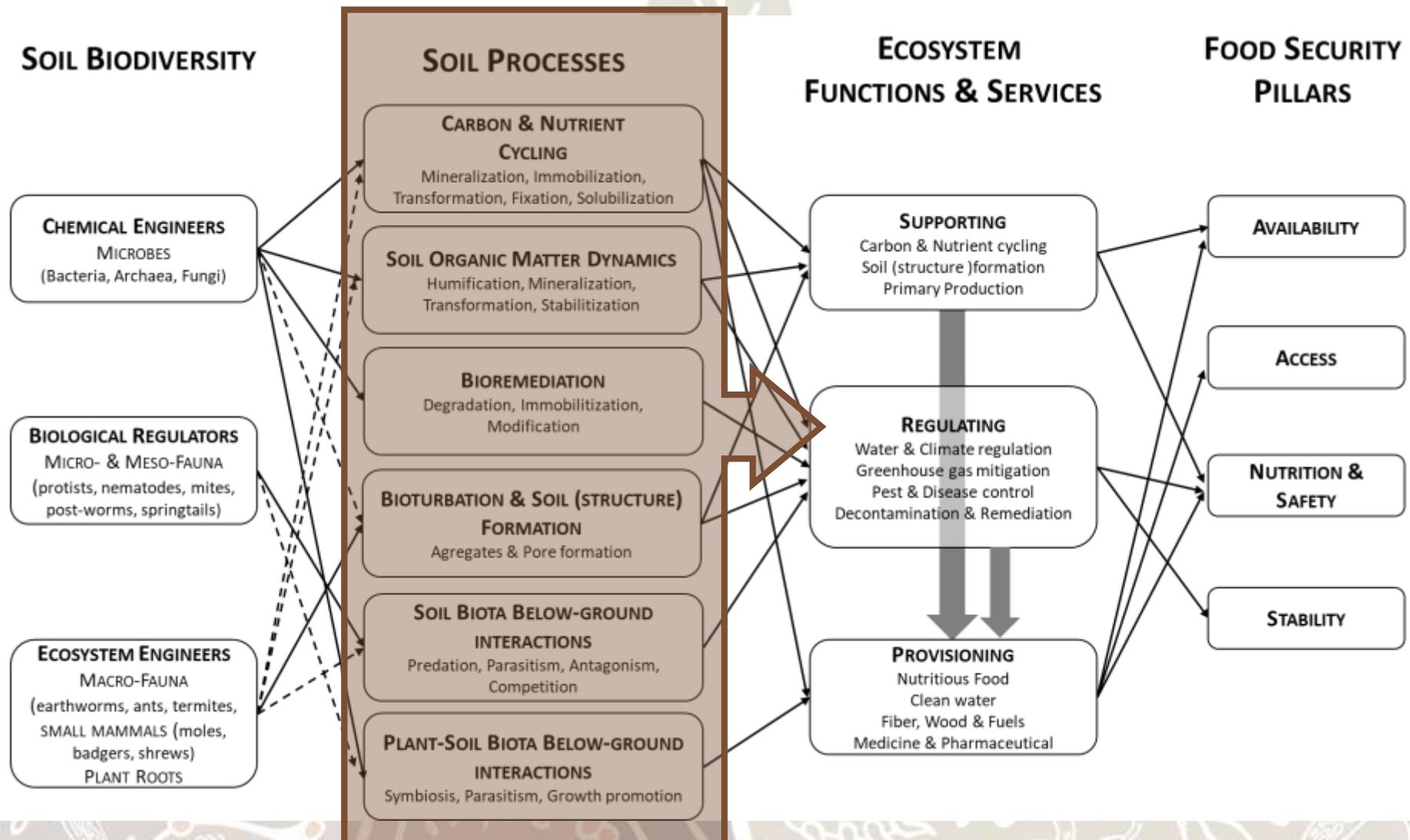
FOOD SECURITY PILLARS

AVAILABILITY

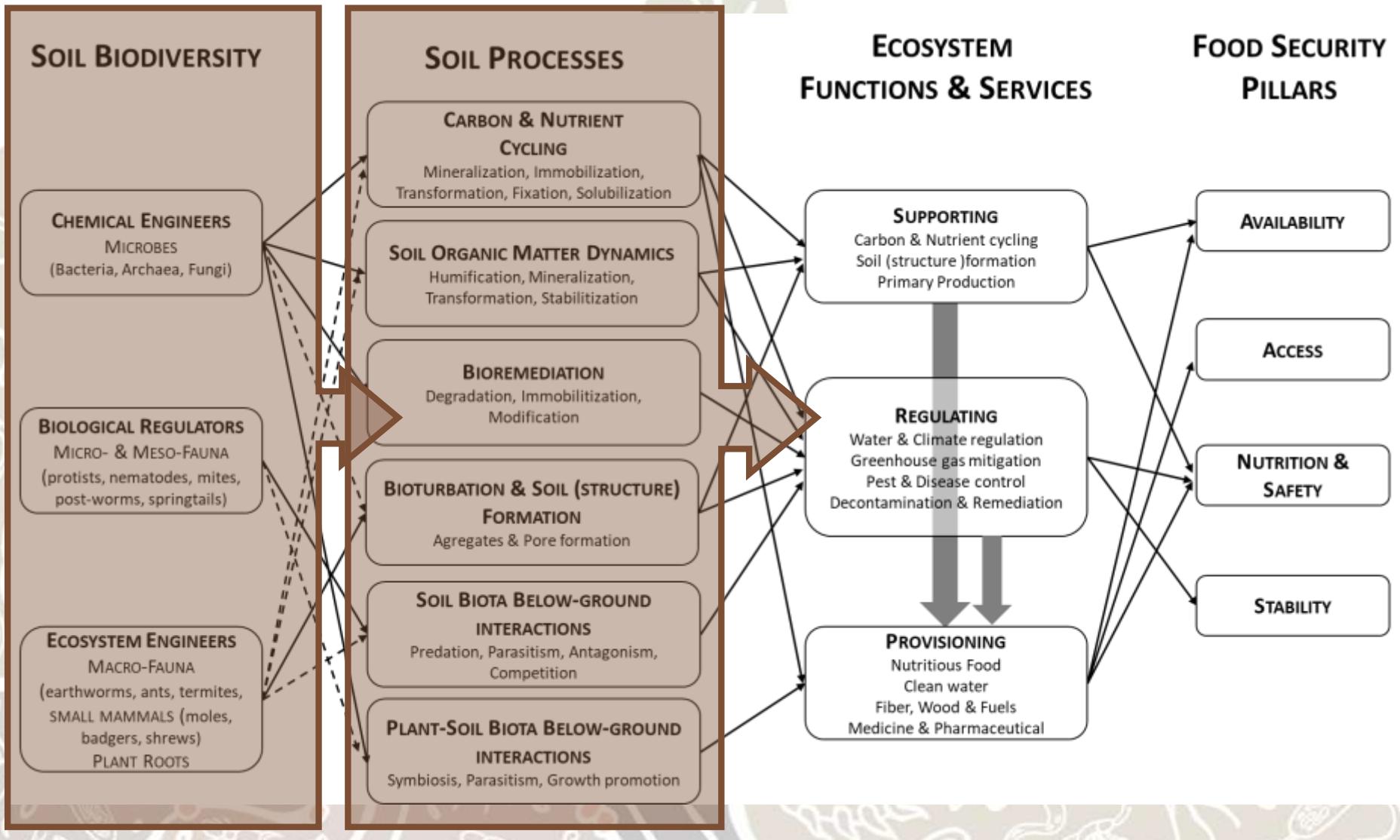
ACCESS

NUTRITION & SAFETY

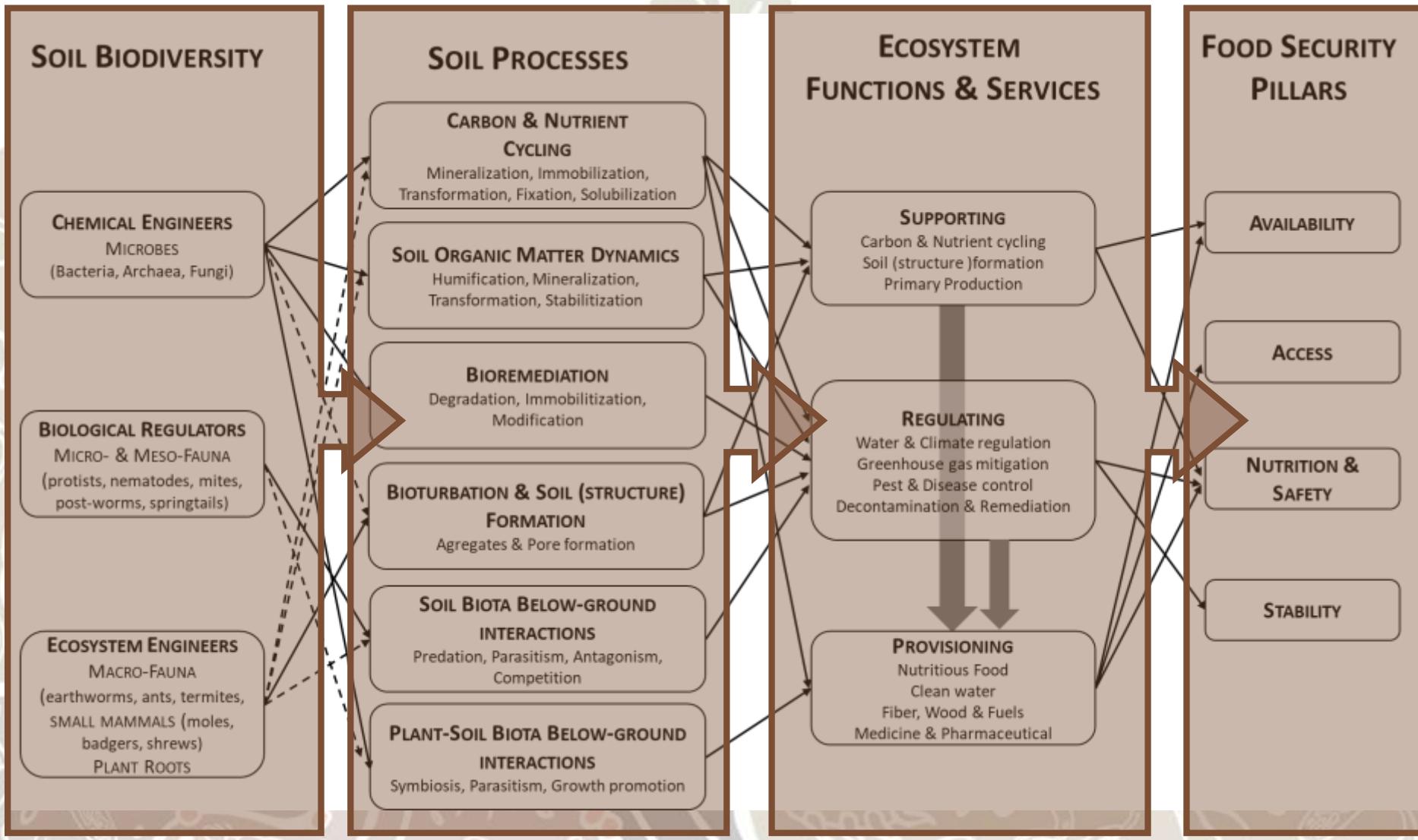
STABILITY



Soil biodiversity management by Holistic Approach



Soil biodiversity management by Holistic Approach



Emerging approaches for soil biodiversity management

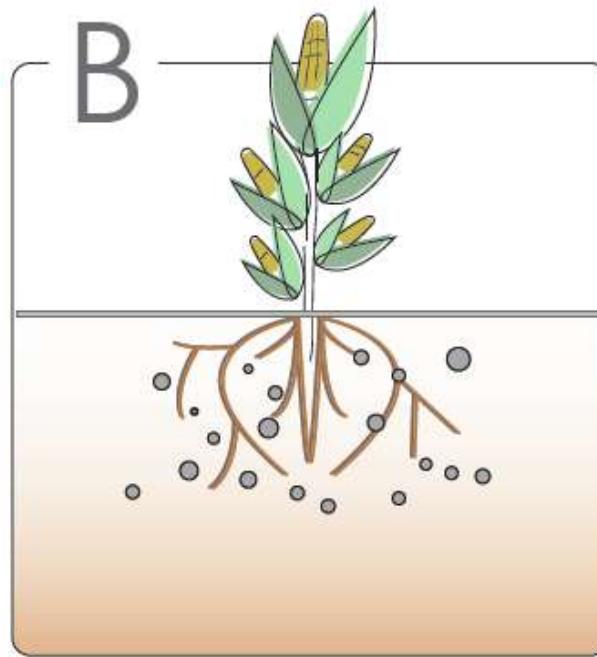
Reductionist Approach

soil-plant interactions
tapping organisms/genes
through biotechnology

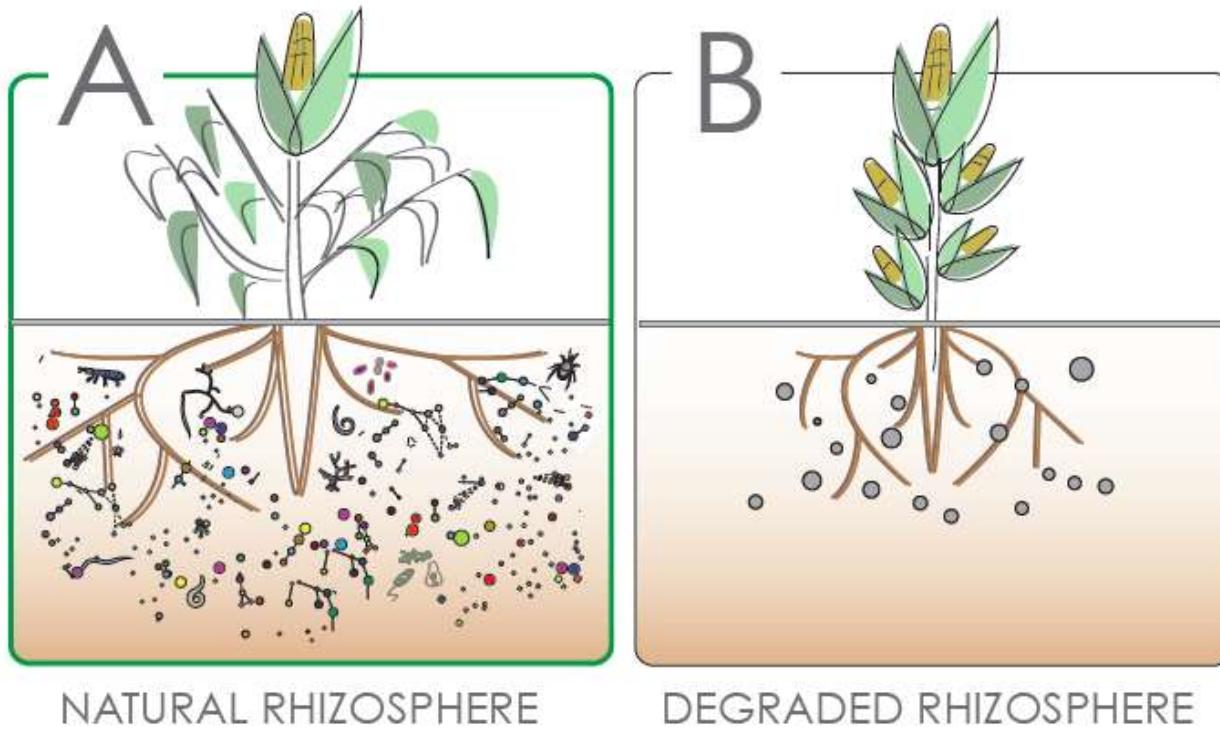
Holistic Approach

managing soil ecosystems & their diversity
→ multifunctionality, resilience & adaptive capacity
complementarity & self-regulation of soil interactions

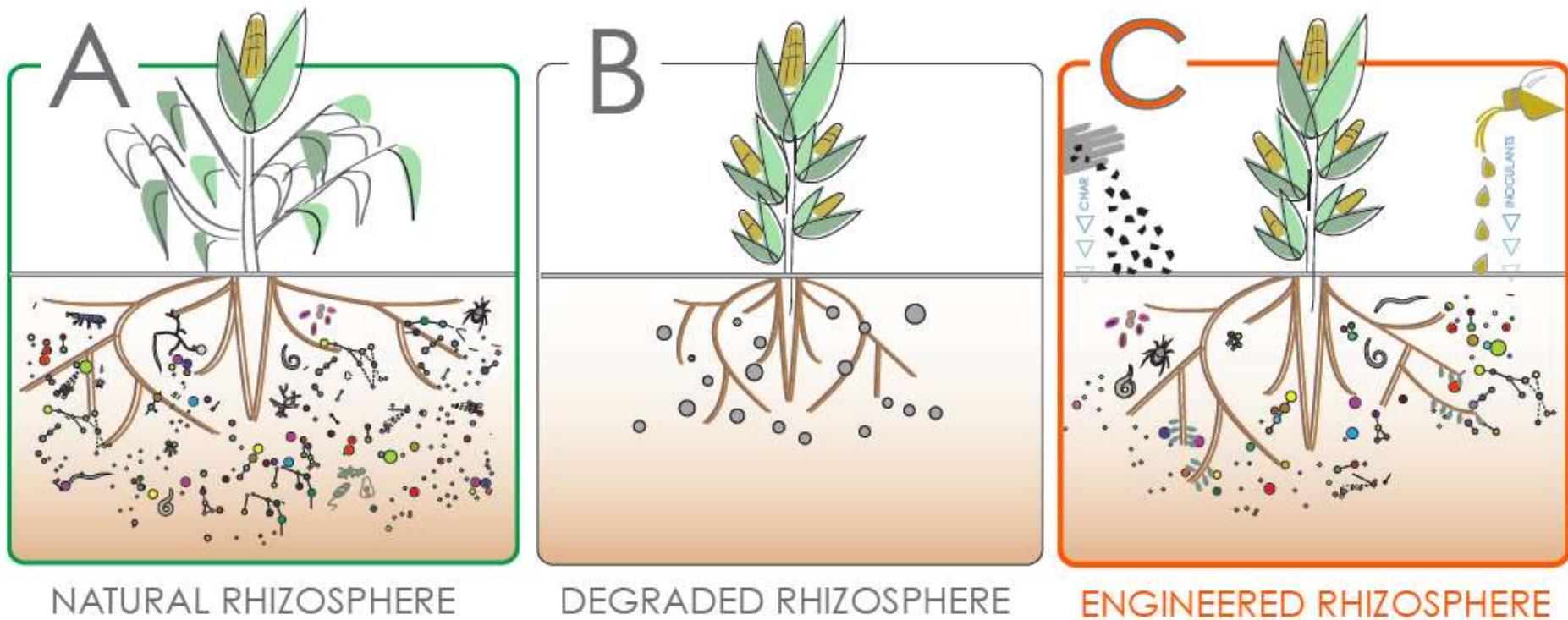
Reductionist approach



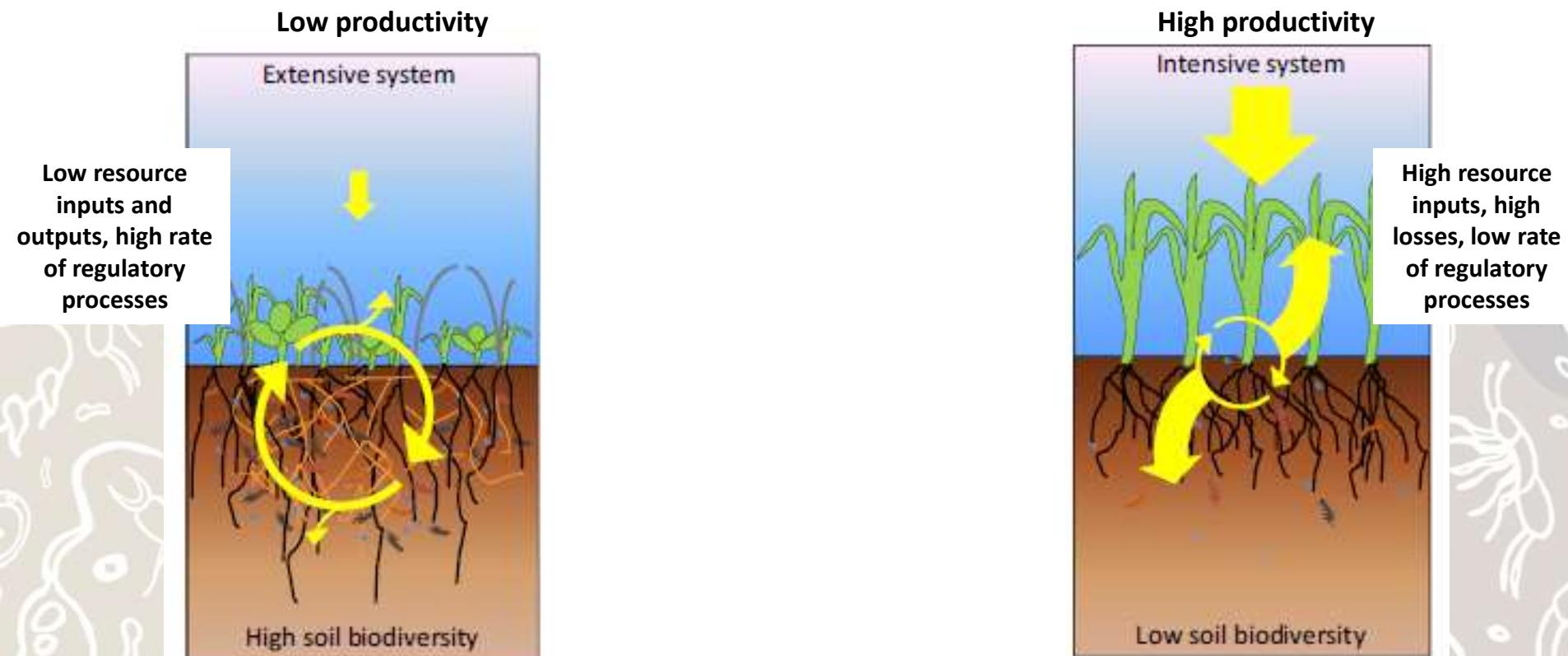
Reductionist approach



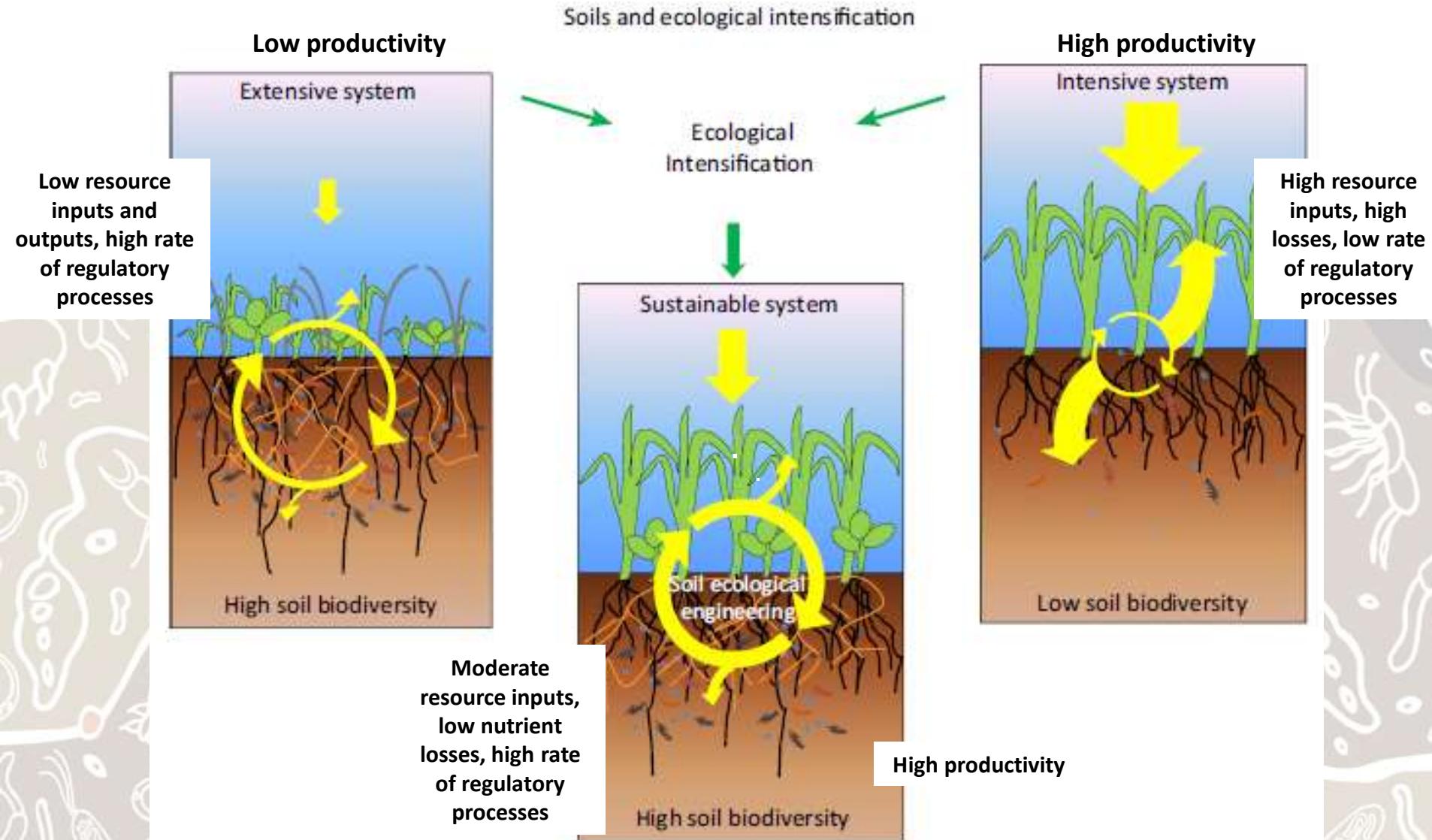
Reductionist approach



Holistic approach



Holistic approach



This knowledge provides direction on how to improve agroecosystems to support food security and other ecosystem services



Thank you for your attention!

