Strengthening climate preparedness and food security through agroecological soil management

Vilnius, 10 June 2024

Pablo Tittonell

Agroécologie et Intensification durable des Cultures Annuelles – Centre de coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

WWF Professor Resilient Landscapes for Nature and People
Groningen University, The Netherlands

Greenhouse Gases Must Begin to Fall by 2025, Says U.N. Climate Report

Emissions rates are still growing every year, though that growth has slowed. The world needs to reach negative growth soon to prevent a potential 3.2°C rise by the end of the century.

By **Jenessa Duncombe** 4 April 2022

Credit: Callum Shaw/Unsplash

Global emissions must peak in just three years to stay below 1.5°C

A major report from the Intergovernmental Panel on Climate Change warns that the window for avoiding more than 1.5°C of global warming has almost closed, with immediate and drastic cuts the only way to stay below the target

ENVIRONMENT 4 April 2022

By **Adam Vaughan**

An aerial view of a coal power plant
Shutterstock/Bilanol

Hunger

There is enough food in the world today for everyone to have the nourishment necessary for a healthy and productive life.

FAQ

HUNGER

1 - Is there a food shortage in the world?

There is enough food in the world today for everyone to have the nourishment necessary for a healthy and productive life.

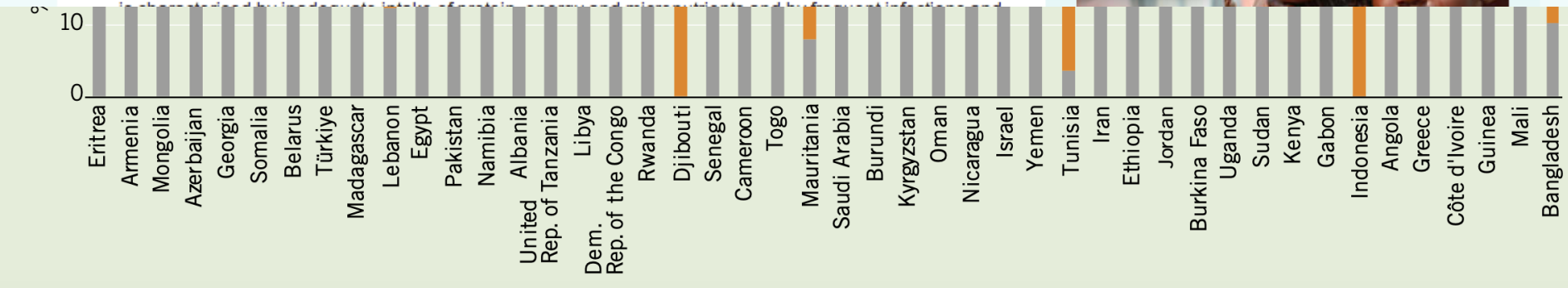
2 - What is hunger?

The sensation of hunger, a lack of food in your stomach, is universal. But there are different manifestations of hunger which are each measured in different ways:

- **Under-nourishment** is used to describe the status of people whose food intake does not include enough calories (energy) to meet minimum physiological needs for an active life. At present, there are 842 million undernourished people worldwide, most of them in developing countries.
- **Malnutrition** means 'badly nourished', but is more than a measure of what we eat or fail to eat. Malnutrition

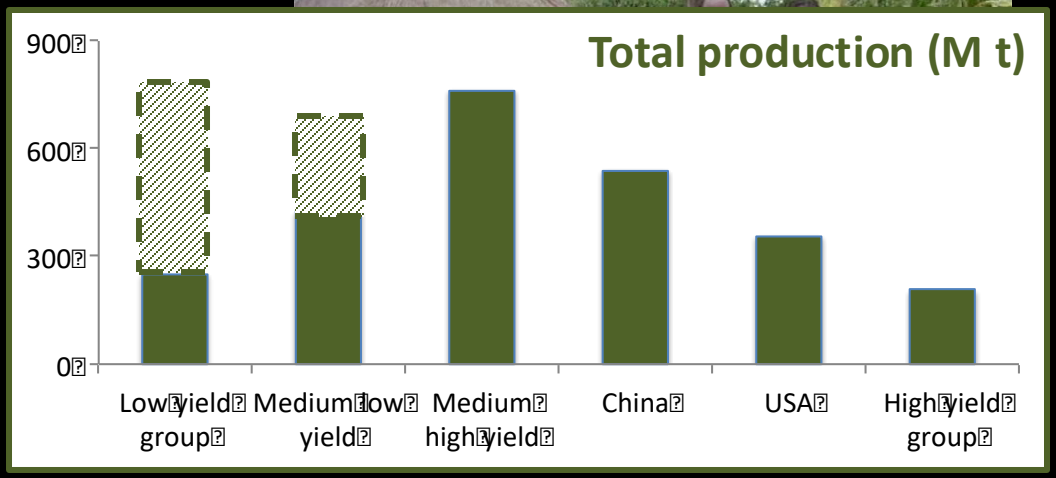
Hunger
The Hungry
Nutrition

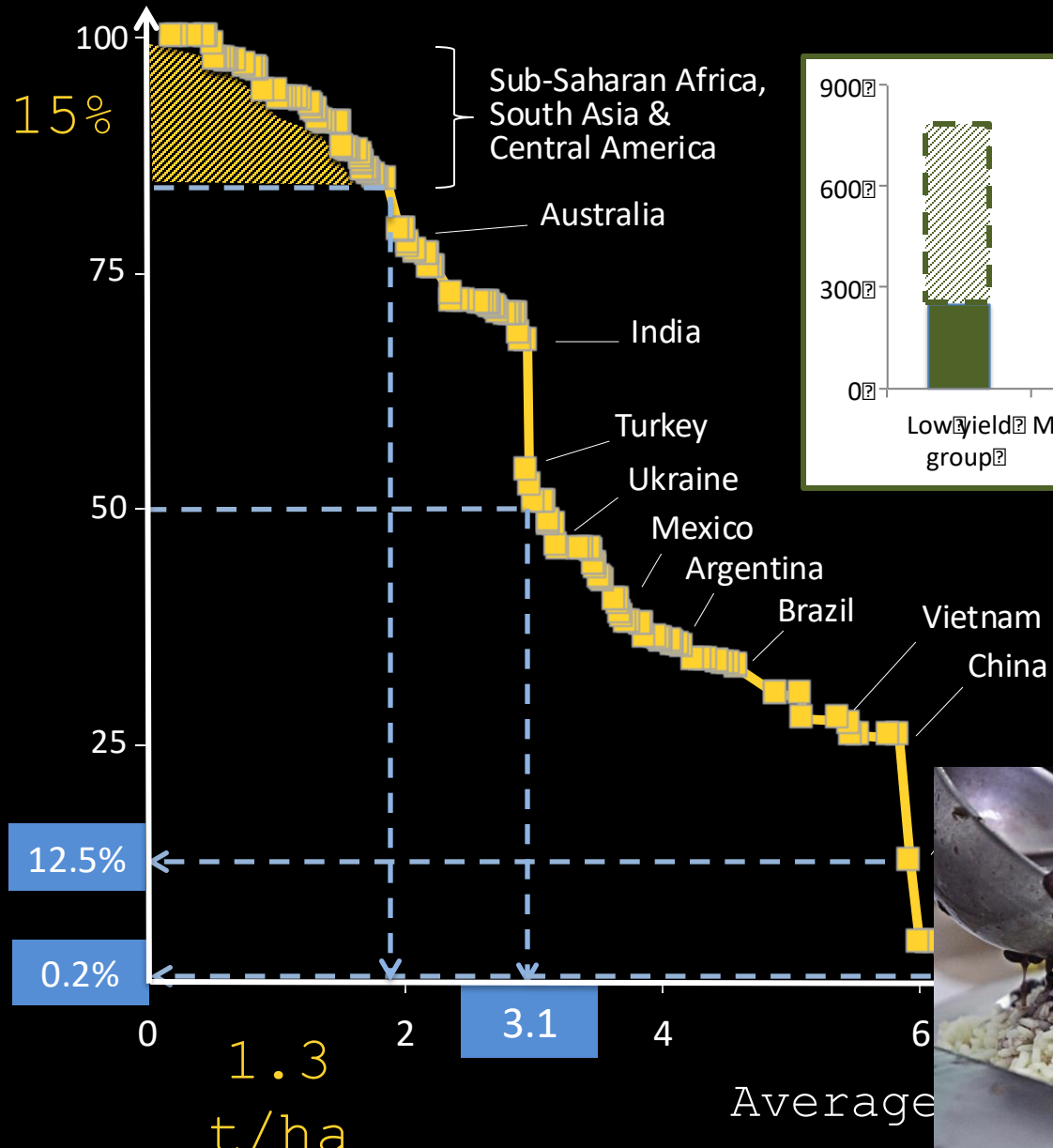
Hunger Stats
Hunger FAQs
Hunger Glossary



Oil extraction from tar-rich sands in Canada’s boreal forest

Contribution to world production (%)





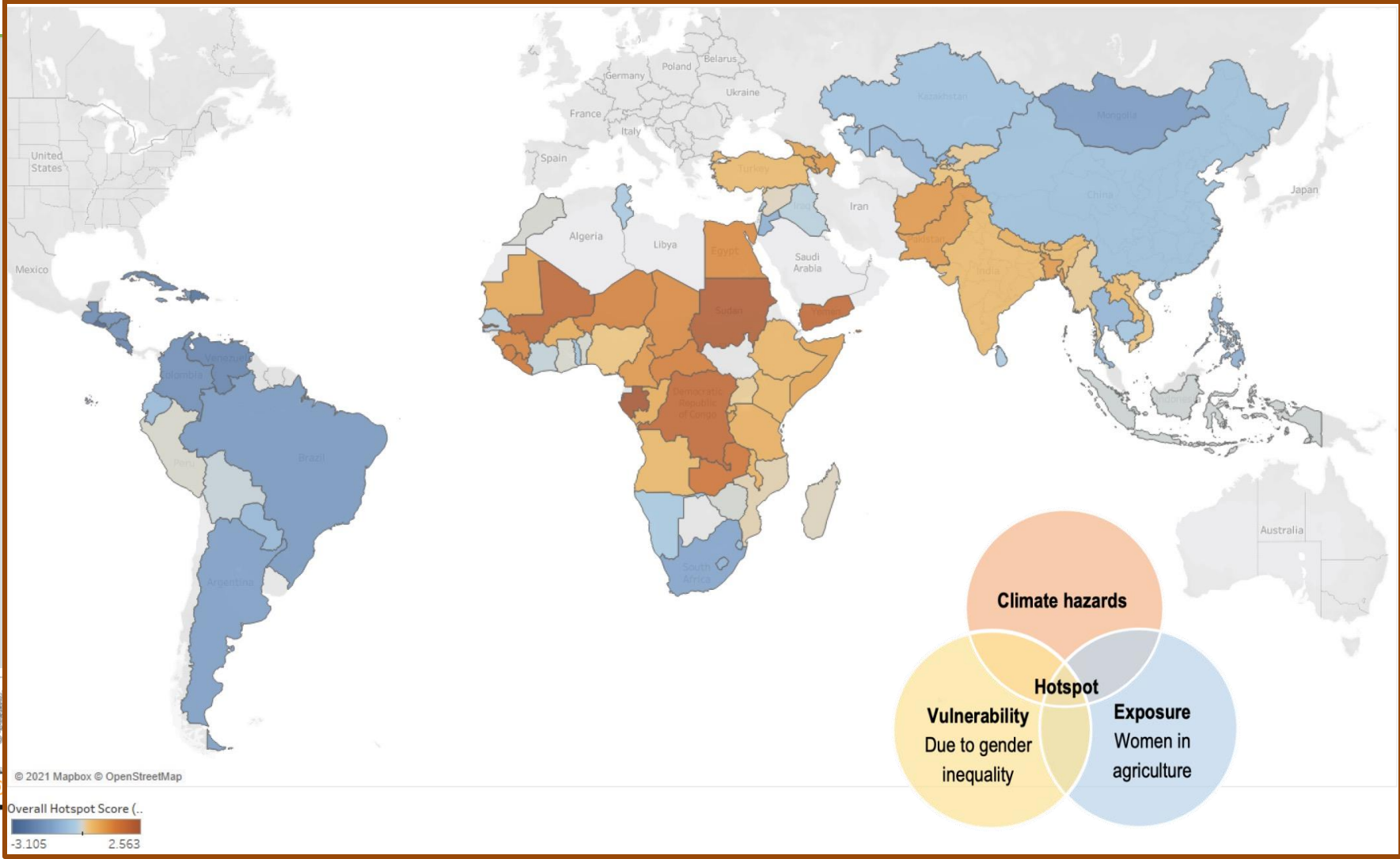
Food security

- ✓ Availability
- ✓ Access
- ✓ Stability
- ✓ Utilisation

Tittonell et al., 2016. Data source: FAOSTAT

Global soil degradation

Gender x climate change vulnerability hospots (CGIAR)



Is agroecology climate smart?

agroecology

the application of ecological principles to the design and mana food sustainable

10 elements that define agroecology (FAO Agroecology Knowledge Hub)


Efficiency


Balance


Diversity


Co-creation of knowledge


Recycling


Synergies


Human and social value


Circular economy


Culture and food traditions


Land and natural resources governance

Is agroecology climate smart?

5

Diversity in Organic
Agroecological Farr
for Mitigation of Cli
Impact, with Examp
America

Literature review (97

Diferencias significativas en

- ✓ Secuestro de carbono ha
- ✓ Eficiencia energética;
- ✓ Capacidad de captura y
- ✓ Resiliencia frente a sequ
- ✓ Resiliencia frente a hura

Sin diferencias significativas

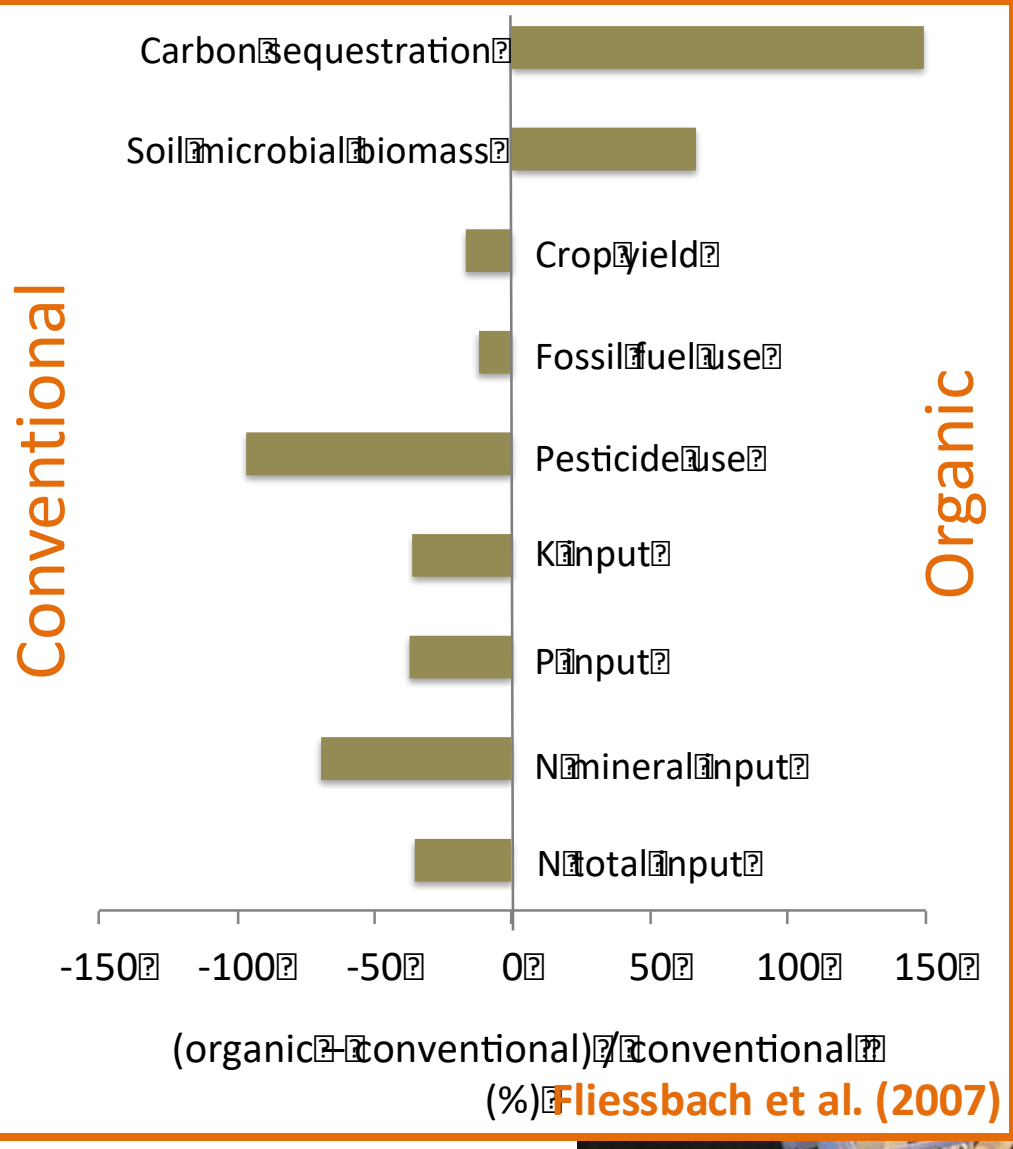
- ➢ Potencial de calentamie
- ➢ Secuestro de carbono ha

5.1

As the largest
both contribute
change. Accordi
Panel on Clim
global warming
due to anthro
Among these, ag
of CH_4 and N_2O

1994

GOK trials (21 years)



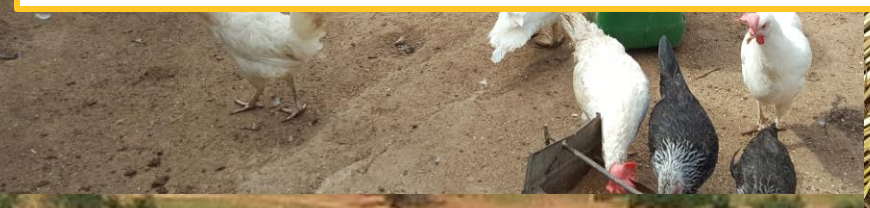
Fliessbach et al. (2007)

...ded soils

Yield-increasing potential of agroecological innovations in Africa

Table 3 Summary of productivity outcomes from African case studies (Pretty et al. 2011)

Thematic focus	Area improved (ha)	Mean yield increase (ratio)
Crop variety and system improvements	391,060	2.18
Agroforestry and soil conservation	3,385,000	1.96
Conservation agriculture	26,057	2.20
Integrated pest management	3,327,000	2.24
Horticulture and very small-scale agriculture	510	nd
Livestock and fodder crops	303,025	nd
Novel regional and national partnerships and policies	5,319,840	2.05
Aquaculture	523	nd
Total	12,753,000	2.13



Restoring soils through agroecology (Kenya)

Contents lists available at SciVerse ScienceDirect

Field

journal homepage

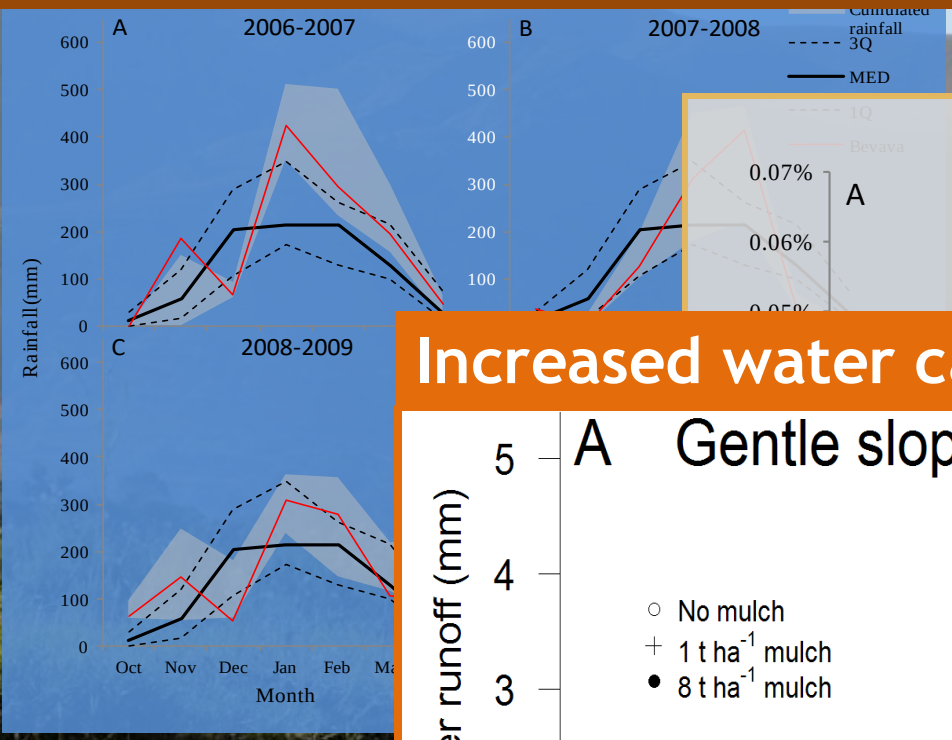
Agroecology-based aggradation-cons innovations to combat soil degradati

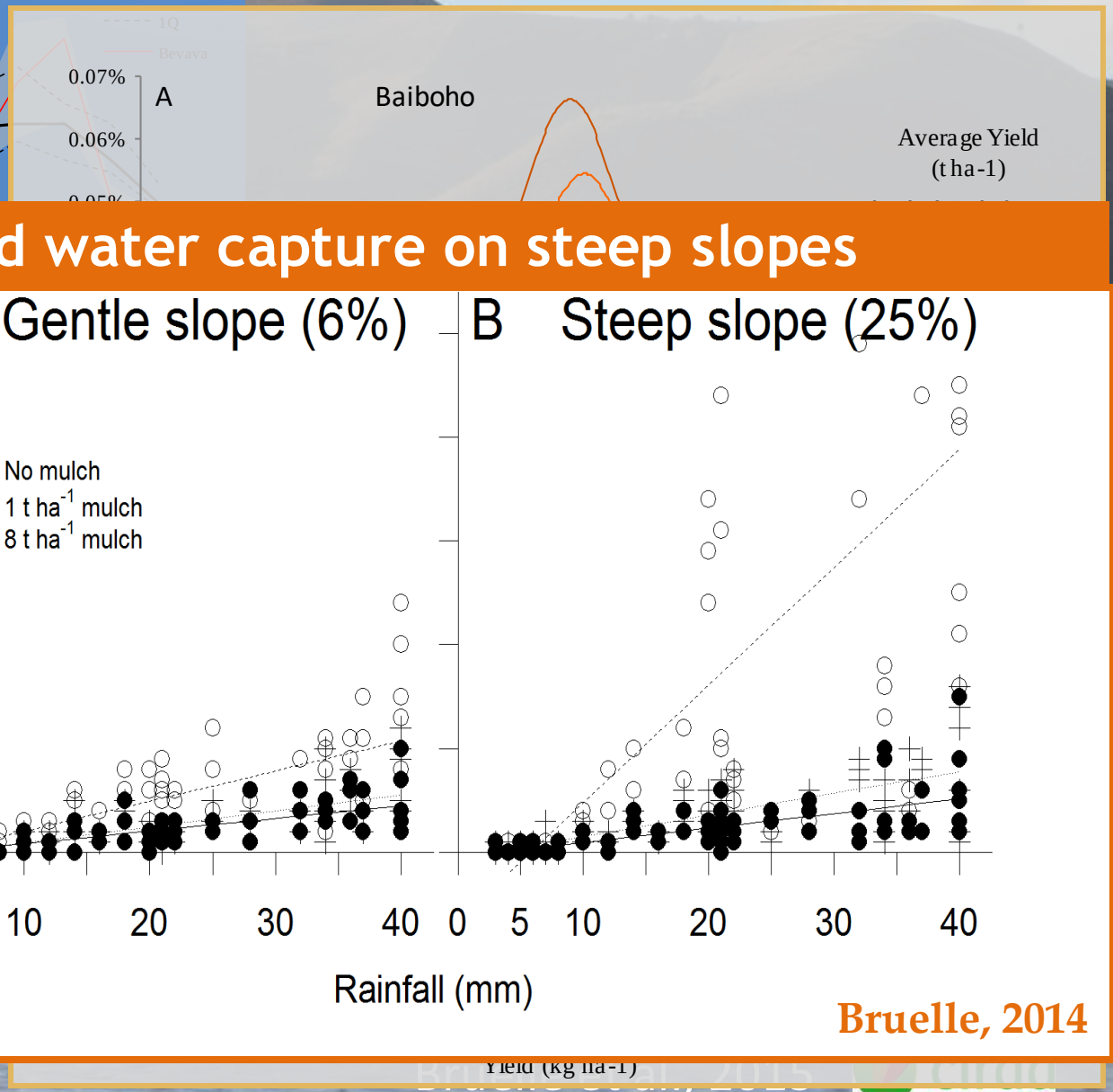
P. Tittonell[a,b,c,d,e,*], E. Scopel[a,j], N. Andrieu[a,g], G.E. van Halsema[f], R. Lahmar[a], S. Lugandu[b,c,d], R. Chikowo[i], K. Naudin[a,j], B. Triomphe[a], S. Mkomwa

[a] Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Avenue Agropolis, 34398 Montpellier cedex 5, France
[b] Africa Conservation Tillage Network, Kenya
[c] Africa Conservation Tillage Network, Tanzania
[d] Africa Conservation Tillage Network, Zimbabwe
[e] Africa Conservation Tillage Network, Burkina Faso
[f] Wageningen University, The Netherlands

Conservation agriculture

Can conservation agriculture reduce climate risks?





Increased water capture on steep slopes

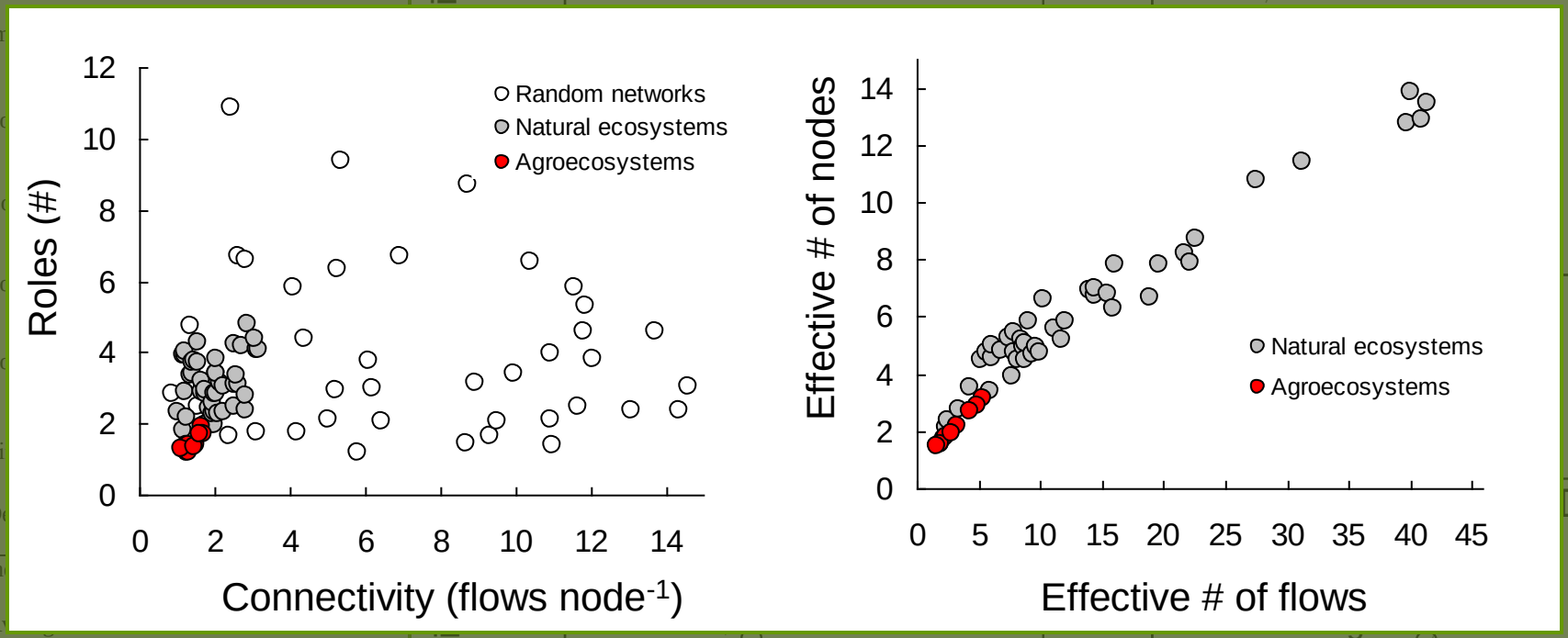
Bruelle, 2014

BV-Lac Project

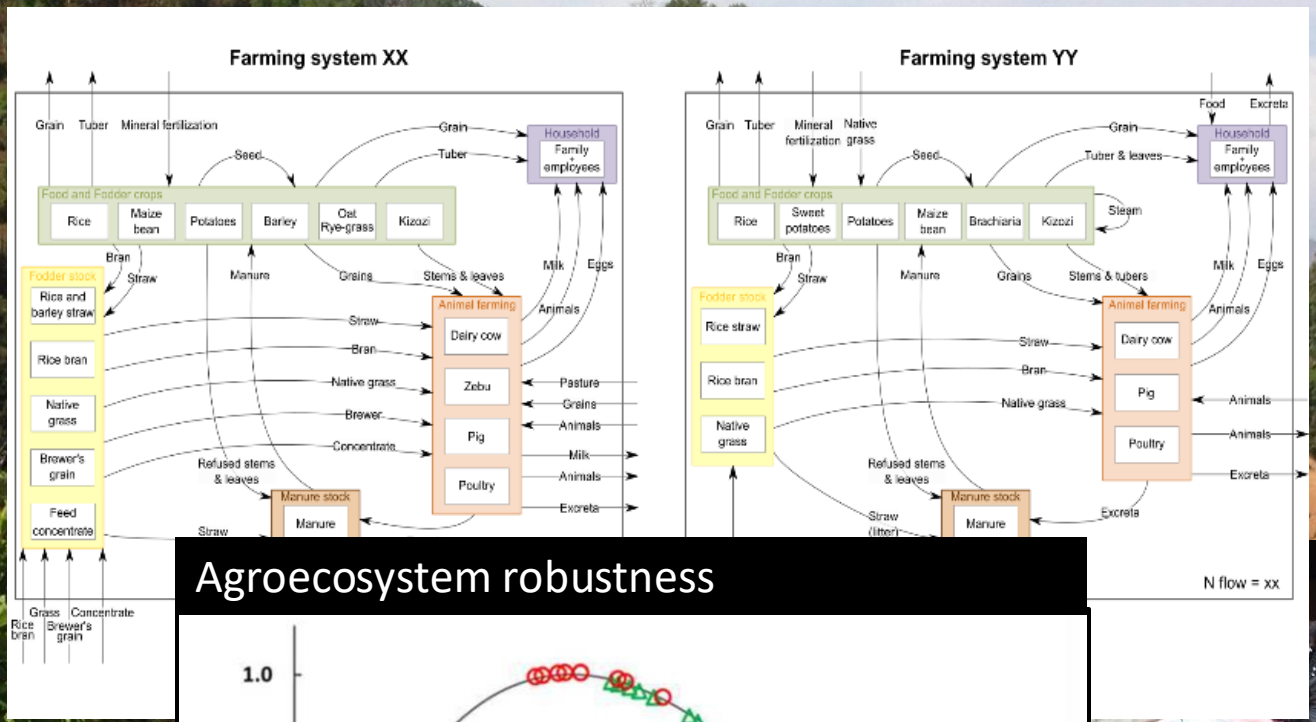
- 3803 upland rice f
- Four years of farm
- Inputs provided o
- Lowlands (Baiboh

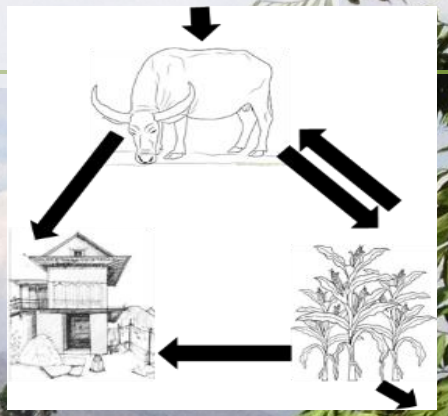
Lake Alaotra, Mad

Complexity/organisation in agroecosystems

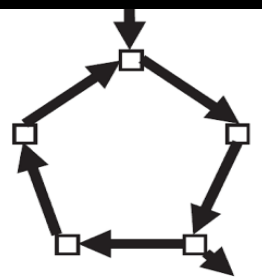


Mid-hills of Nepal (PhD Victoria Alomia)

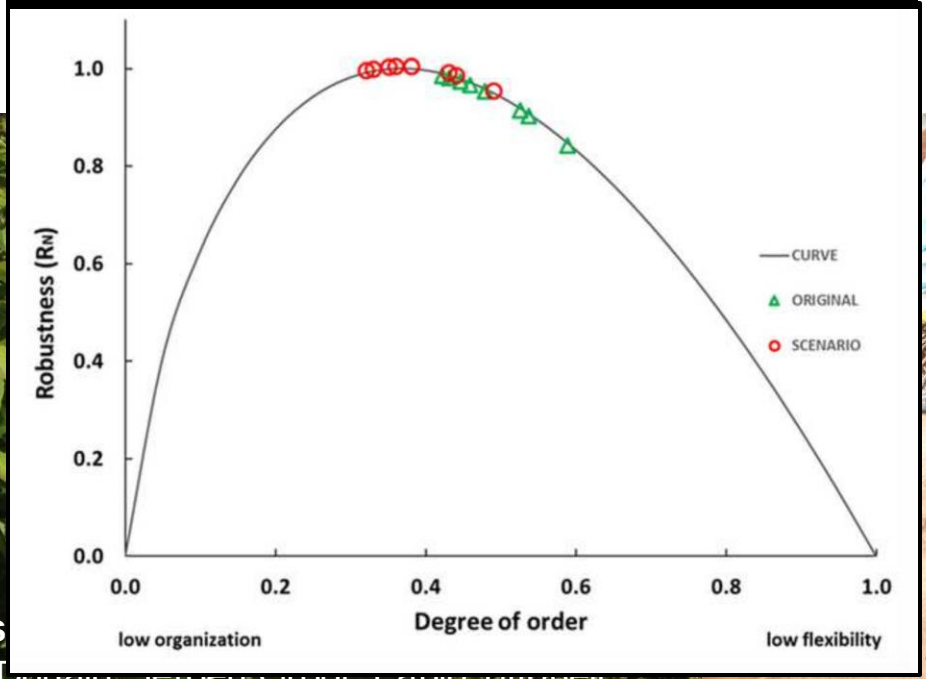




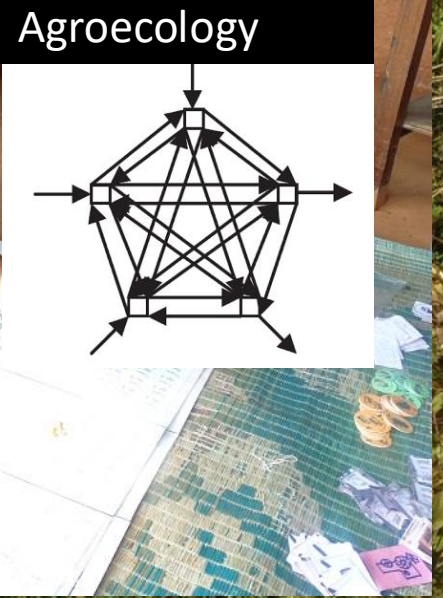
Circular farming



Agroecosystem robustness



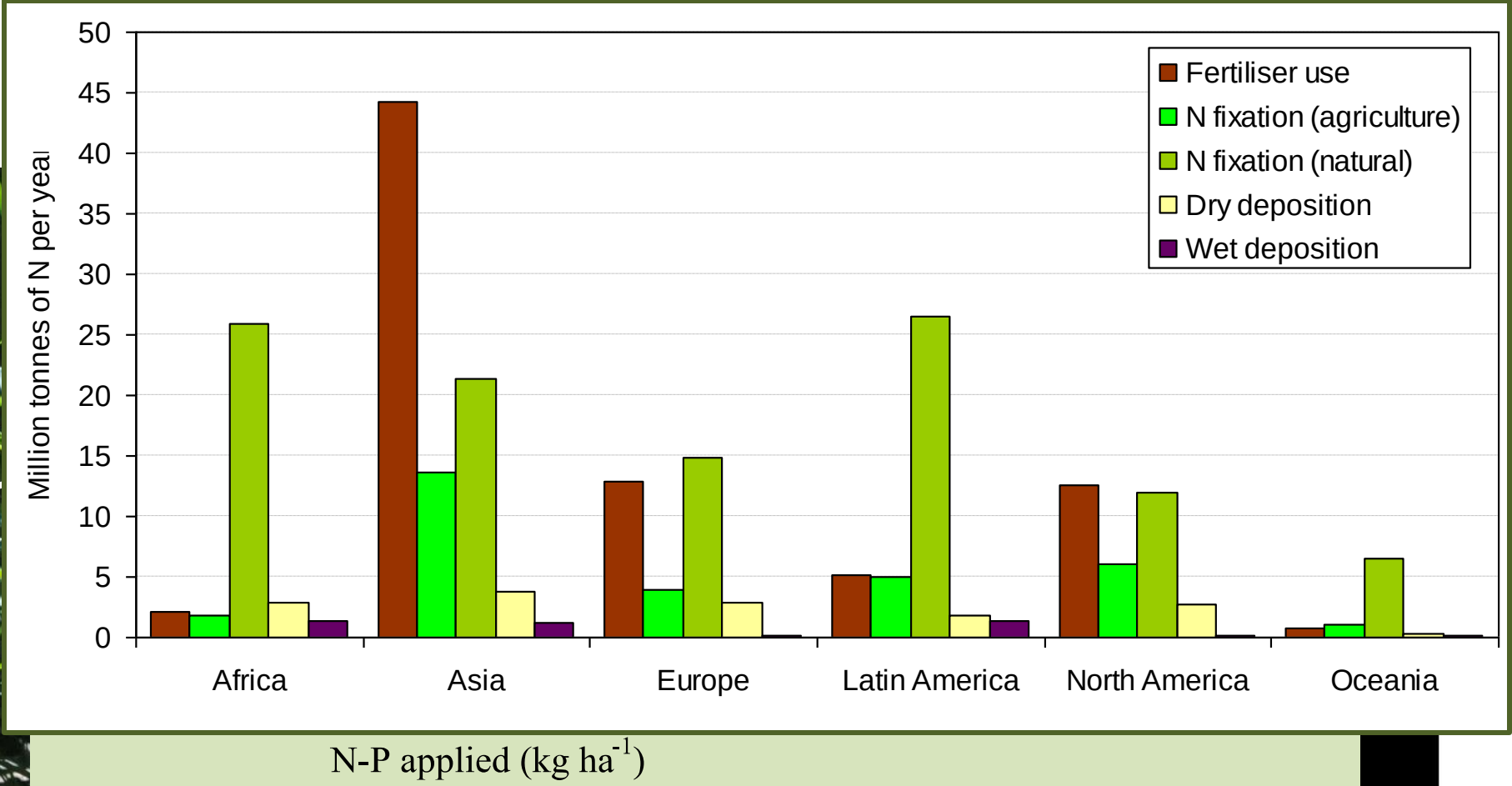
Agroecology



Supervis
Andy McDonald, Jeroen Groot, Pablo Tittonell

Biological N2 fixation

Anthropogenic and natural N inflows per continent



N-P applied (kg ha^{-1})

Fig. 3. Effect of intercropping, rotation, and N and P fertilisation on maize–grain yield in Ruaca in the third (2010/2011) season.

ize after
eonpea

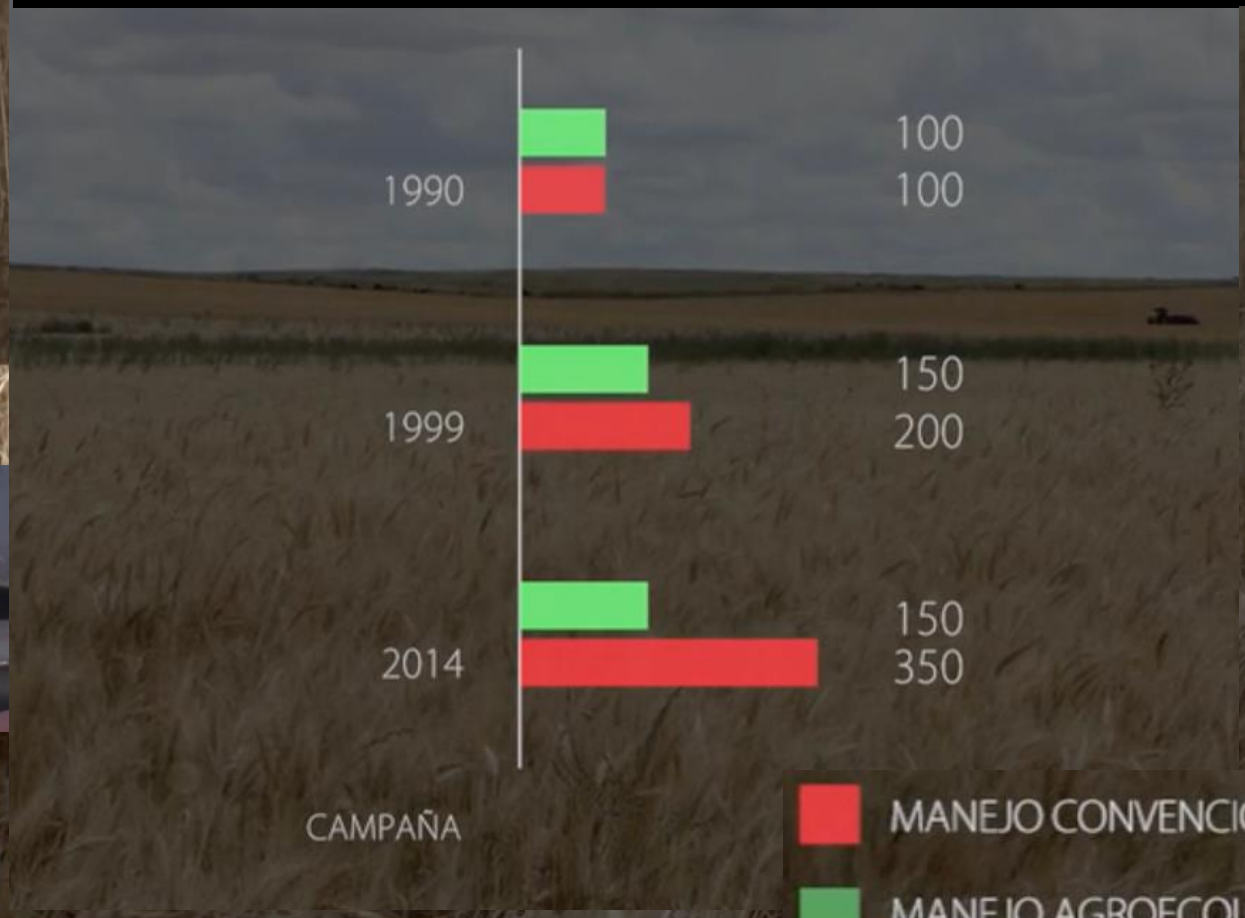
Ruzinamoozi et al., 2012

Co-innovation

Co-innovation: a dialogue of wisdoms

Agroecological intensification (Argentina)

Production costs (US$/ha)



Oats/ Vicia
2011

Sorghum/ soy
2011/12

Agroecological

Durum
wheat/ red
clover
2012

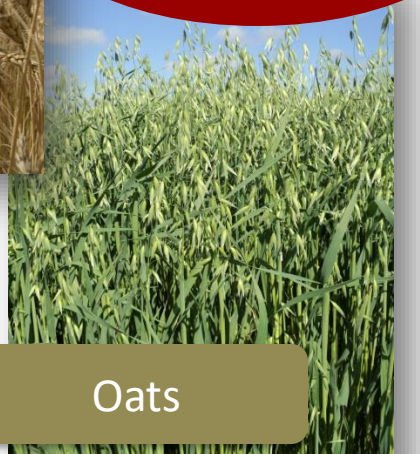
Oats/ Vicia/
red clover
2013

Oats

Soy

Durum wheat

Current (high
input)



Oats

Agroecological

Current (high input)

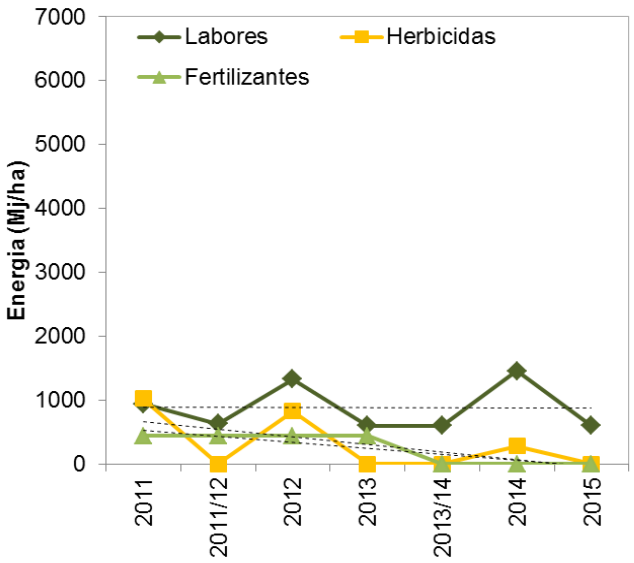
Year	Agroecológico	Actual
Crop diversity		
Rye husks	1500 kg/ha	0

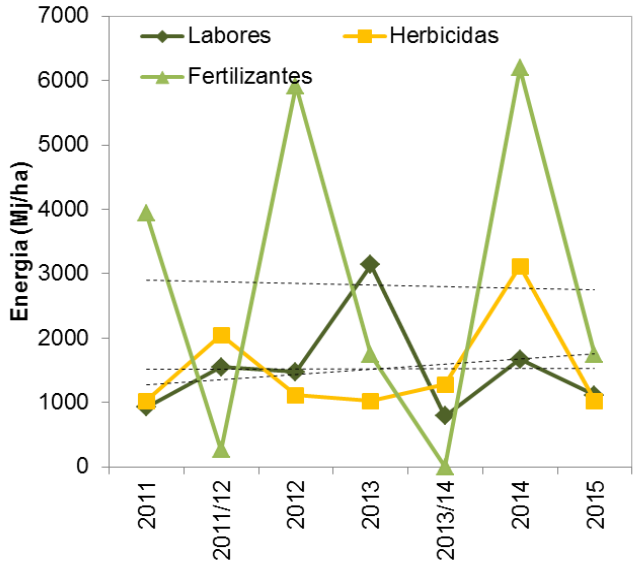
Larger margins, lower costs, less climatic risk

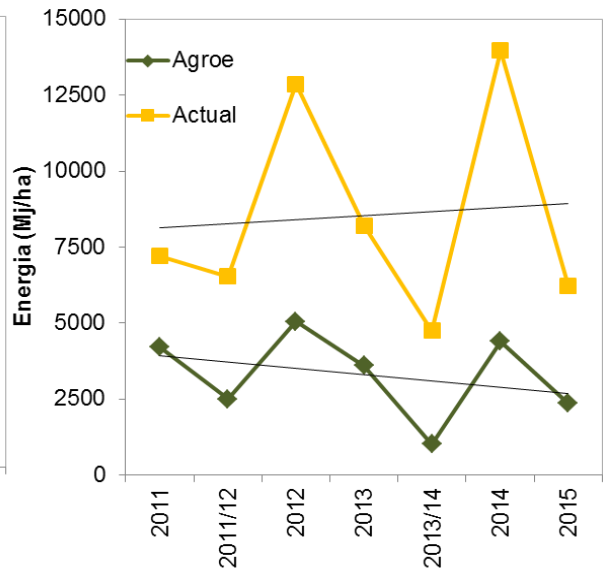
Economic results (us$/ha)

4000

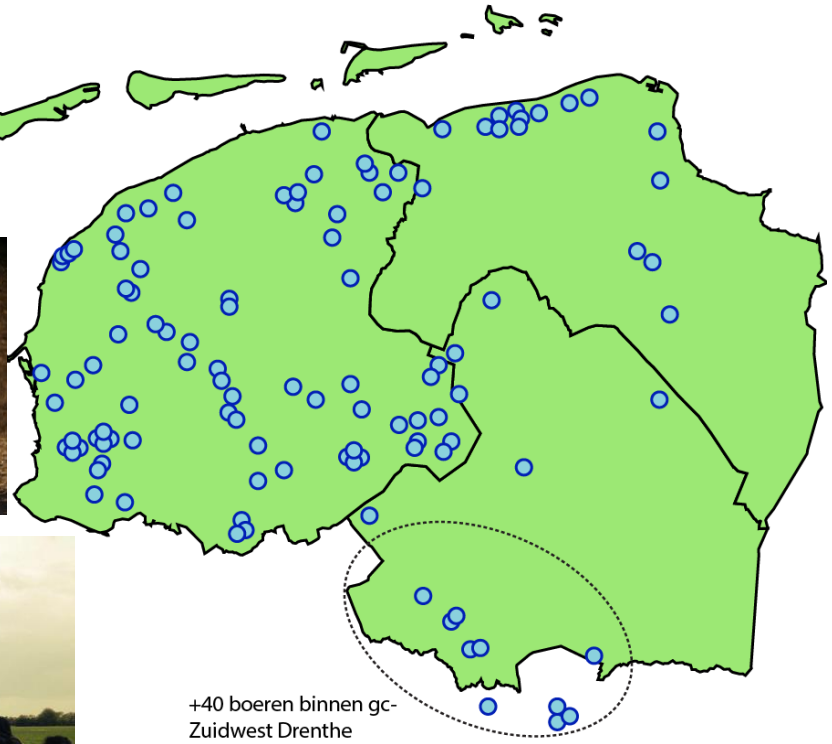
Lower energy costs





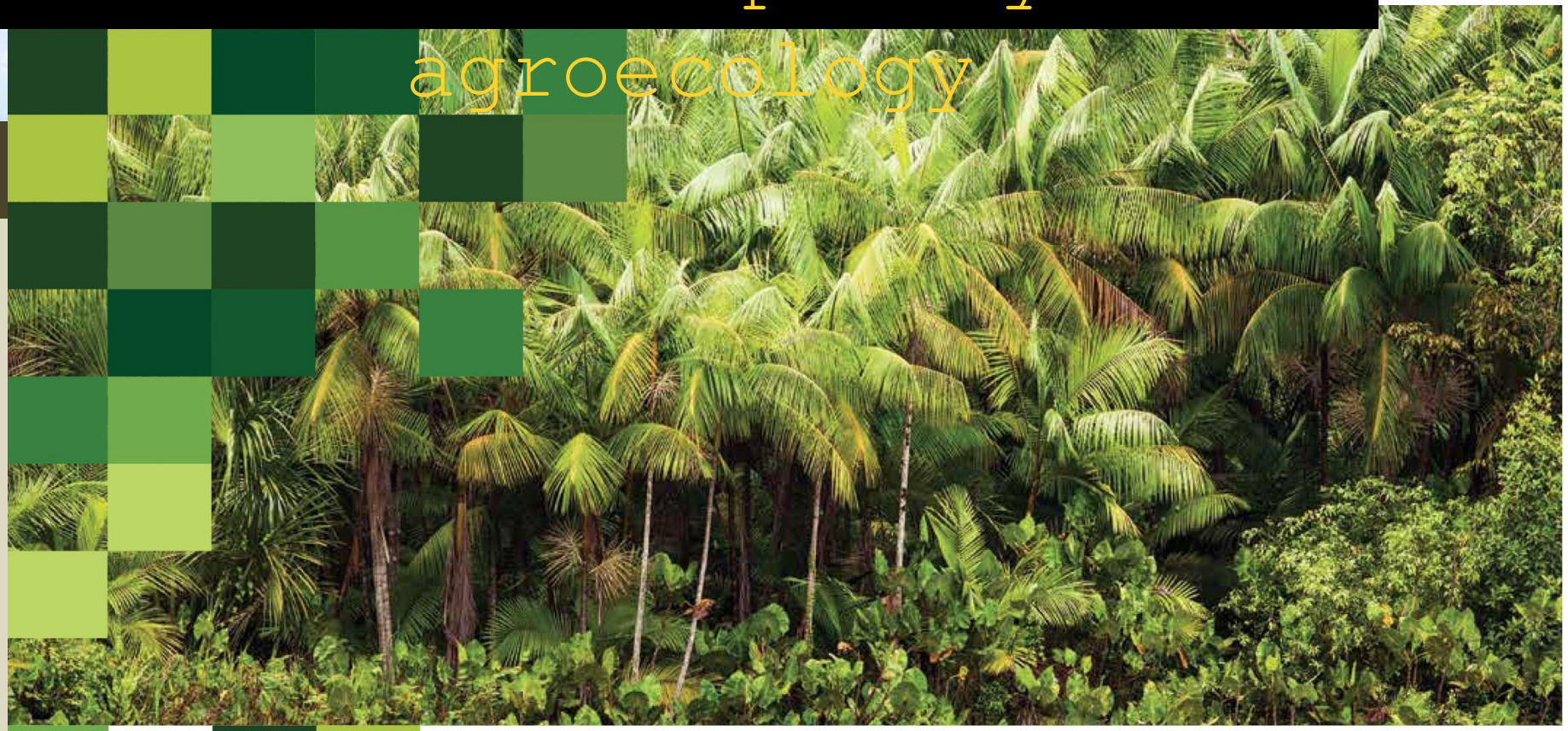


Innovation Platform on **A**groecology, **Re**generative and **N**ature-driven **A**griculture in the North of The Netherlands



Agroecology at scale

A national policy on agroecology



Brasil agroecológico

Plano Nacional de Agroecologia e Produção Orgânica - Planapo

- Educação Cidadã e Mobilização Social
- Doações
- As Parcerias com Empresas e Entidades

Ministério do Desenvolvimento Agrário

BRASIL UM PAÍS DE TODOS GOVERNO FEDERAL

...nas Gerais, Brazil

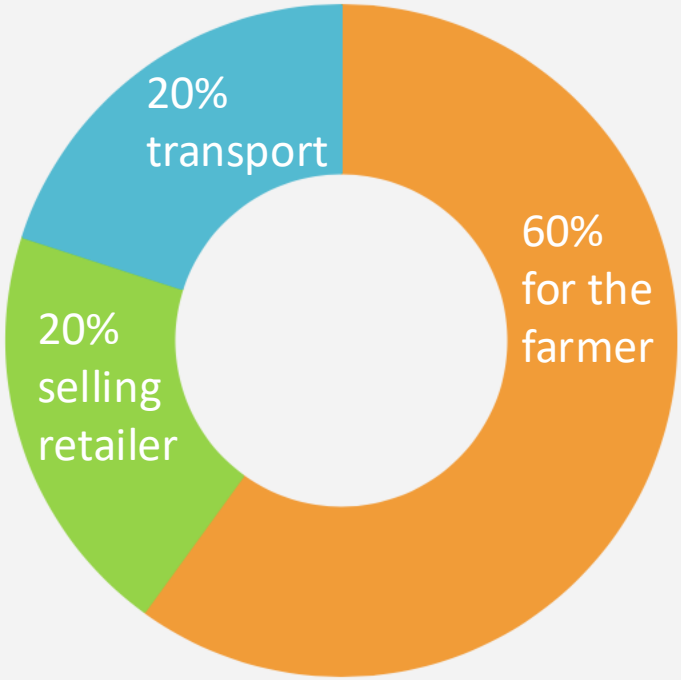
Farmer training on Agroecology

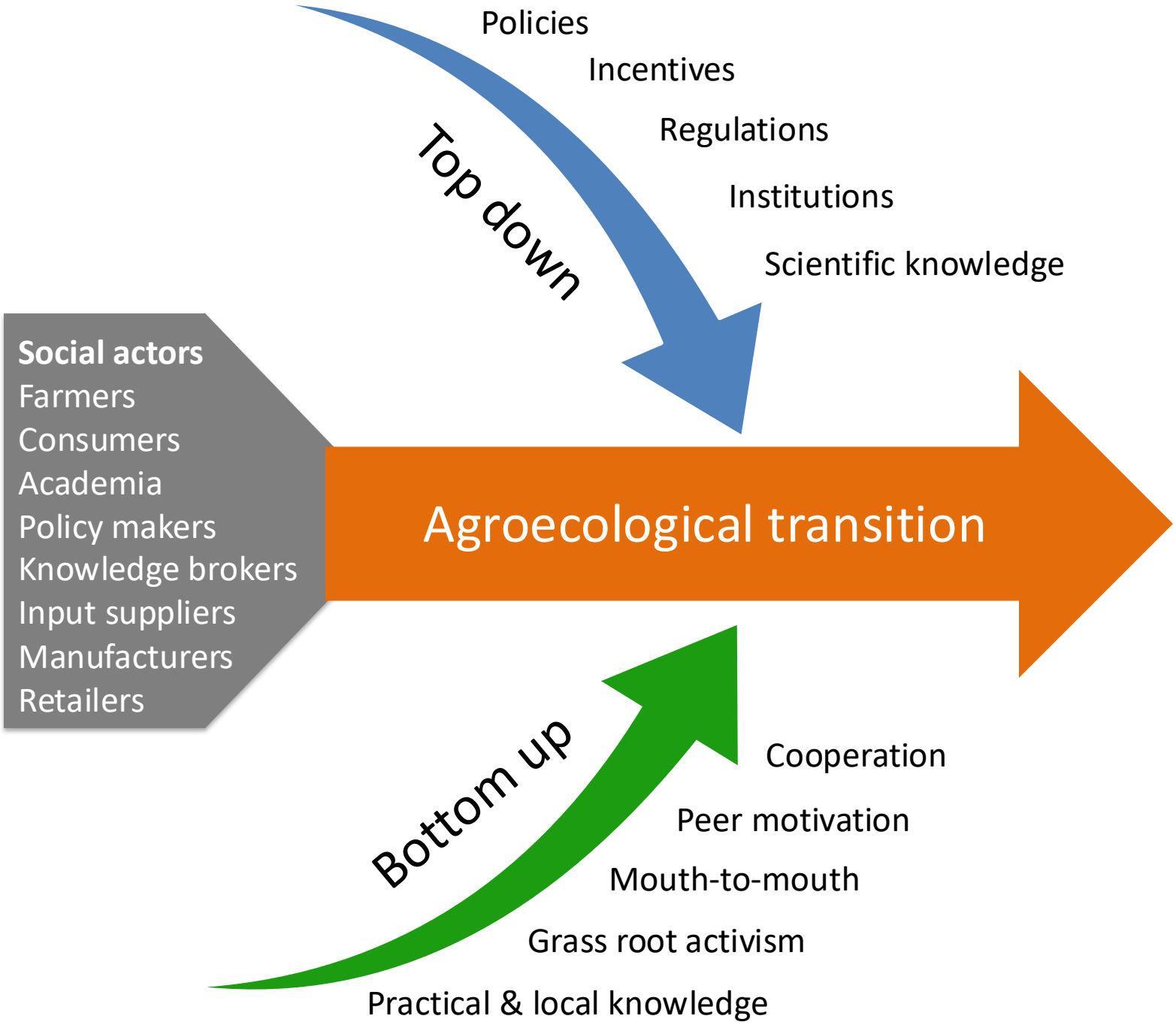
412

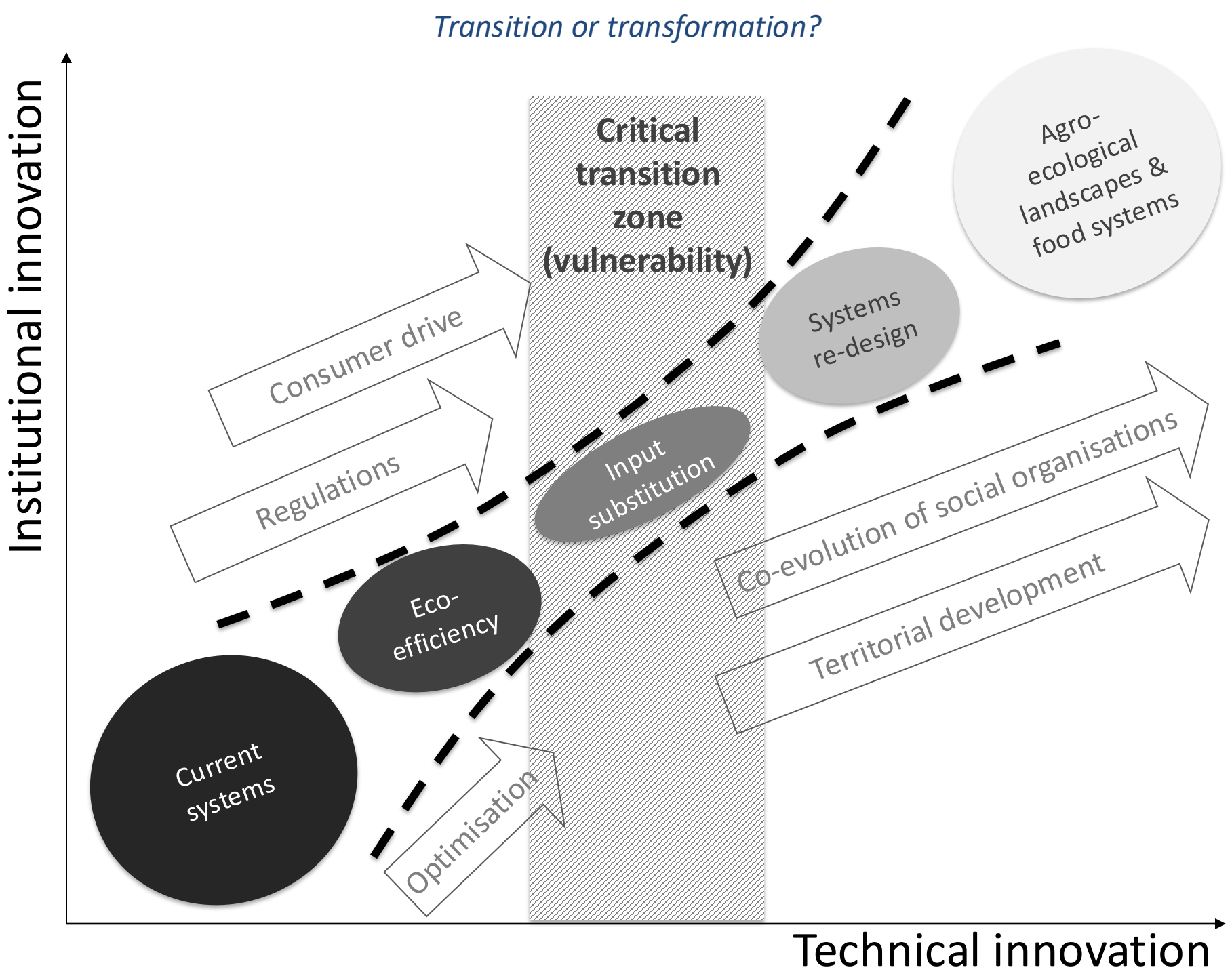
Selling points

Business

Producin , pesticide free, lov

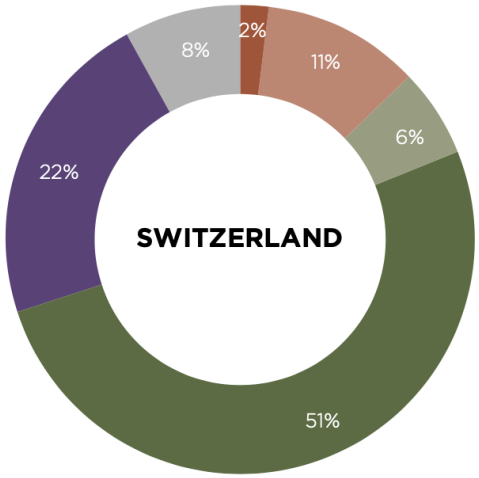


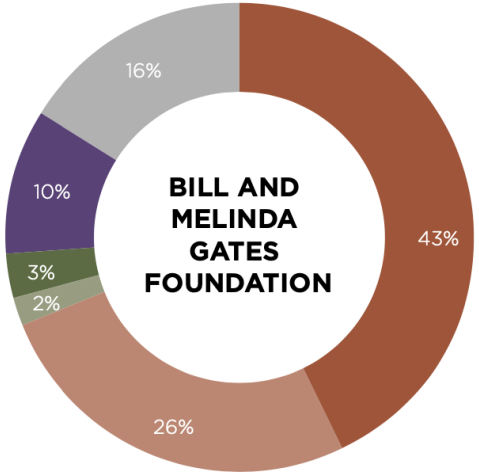

Policies
Incentives
Regulations
Institutions
Scientific knowledge
Top down
Social actors
Farmers
Consumers
Academia
Policy makers
Knowledge brokers
Input suppliers
Manufacturers
Retailers
Agroecological transition
Bottom up
Cooperation
Peer motivation
Mouth-to-mouth
Grass root activism
Practical & local knowledge

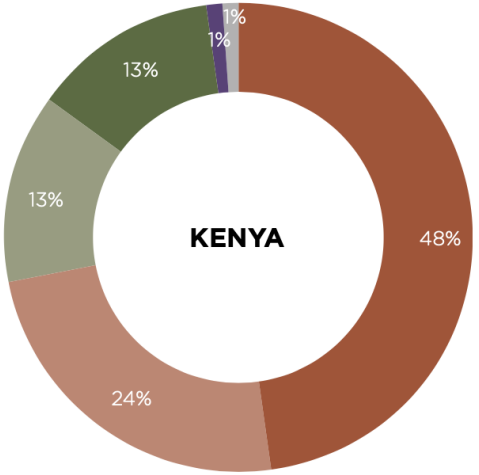

Transition or transformation?
Institutional innovation
Technical innovation
Critical transition zone (vulnerability)
Agro-ecological landscapes & food systems
Systems re-design
Consumer drive
Regulations
Input substitution
Co-evolution of social organisations
Territorial development
Eco-efficiency
Current systems
Optimisation

Donor investment in agroecology

Overview of the degree to which agroecology has been integrated in AgR4D projects in three case studies







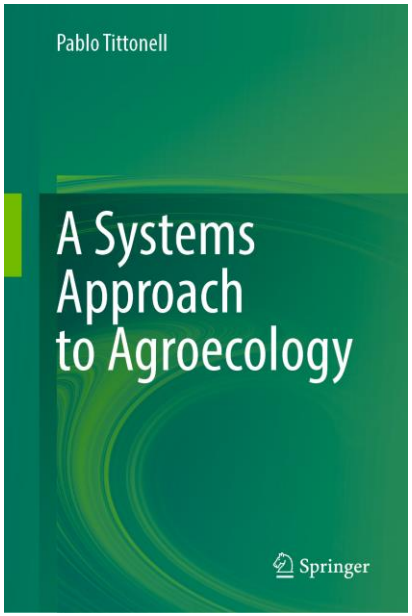
- Level 0: Industrial agriculture only
- Level 1: Improved efficiency of industrial practices
- Level 2: Substitution of industrial inputs
- Level 3 present: Redesigned agroecosystem
- Levels 4-5 only: Socioeconomic environment
- Symptoms or neutral projects

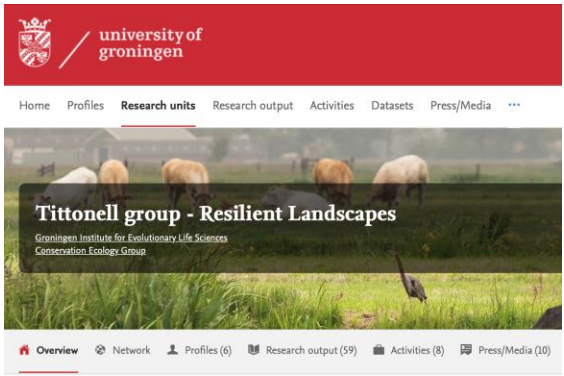
Biovision Foundation for Ecological Development & IPES-Food. 2020. Money Flows: What is holding back investment in agroecological research for Africa? Biovision Foundation for Ecological Development & International Panel of Experts on Sustainable Food Systems

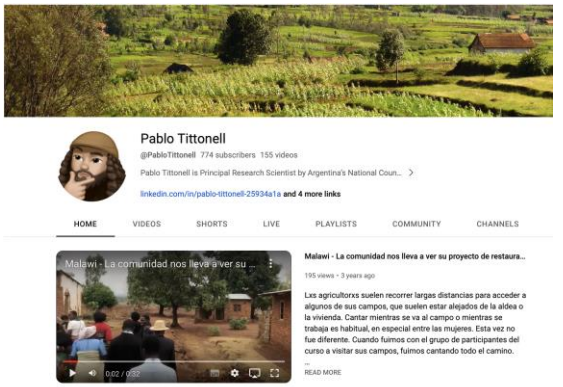
Thanks!

The Slow Blog

www.pablotittonell.org







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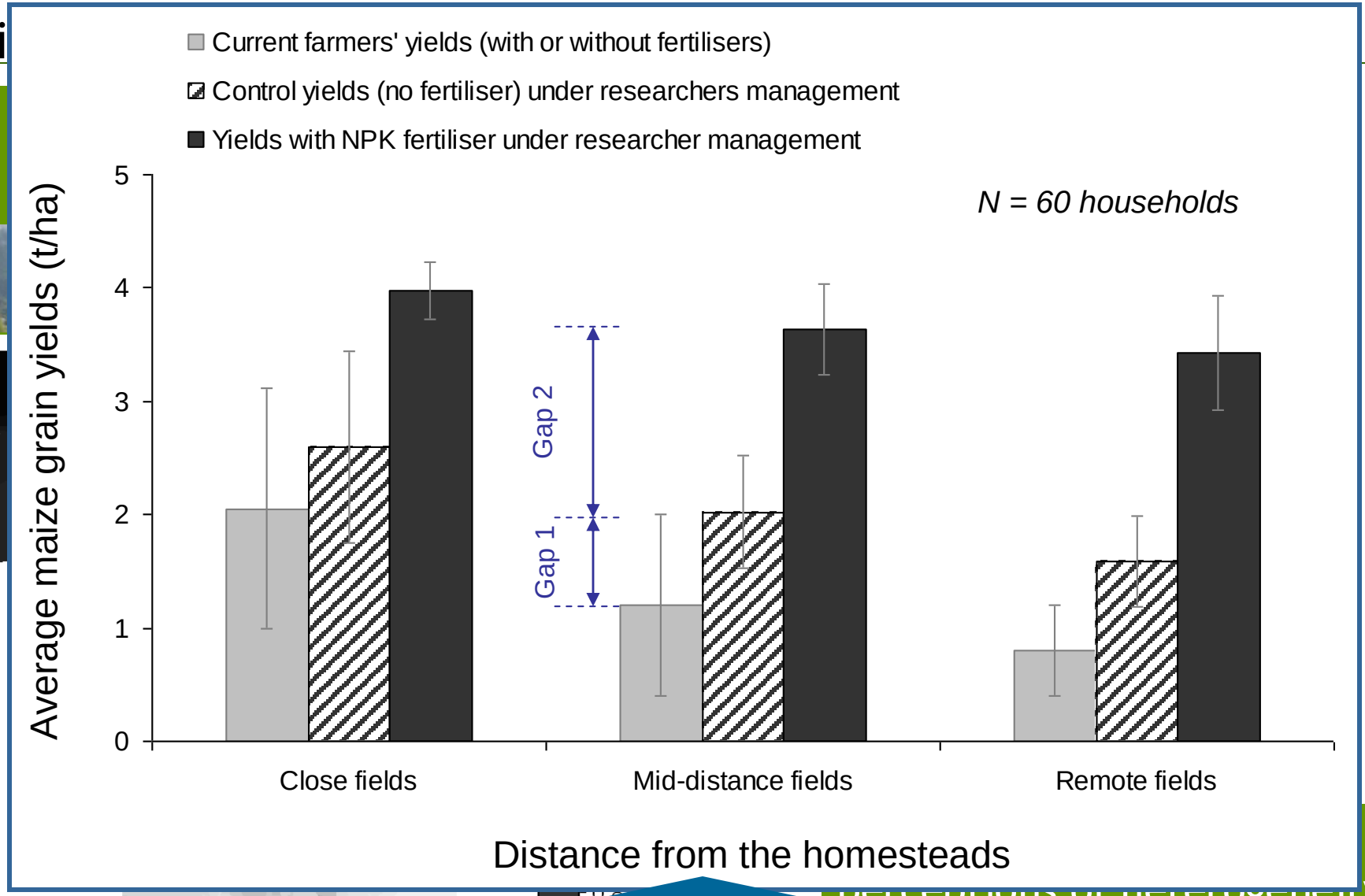
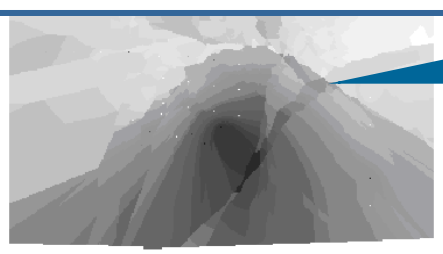




Ebanyat, 2010

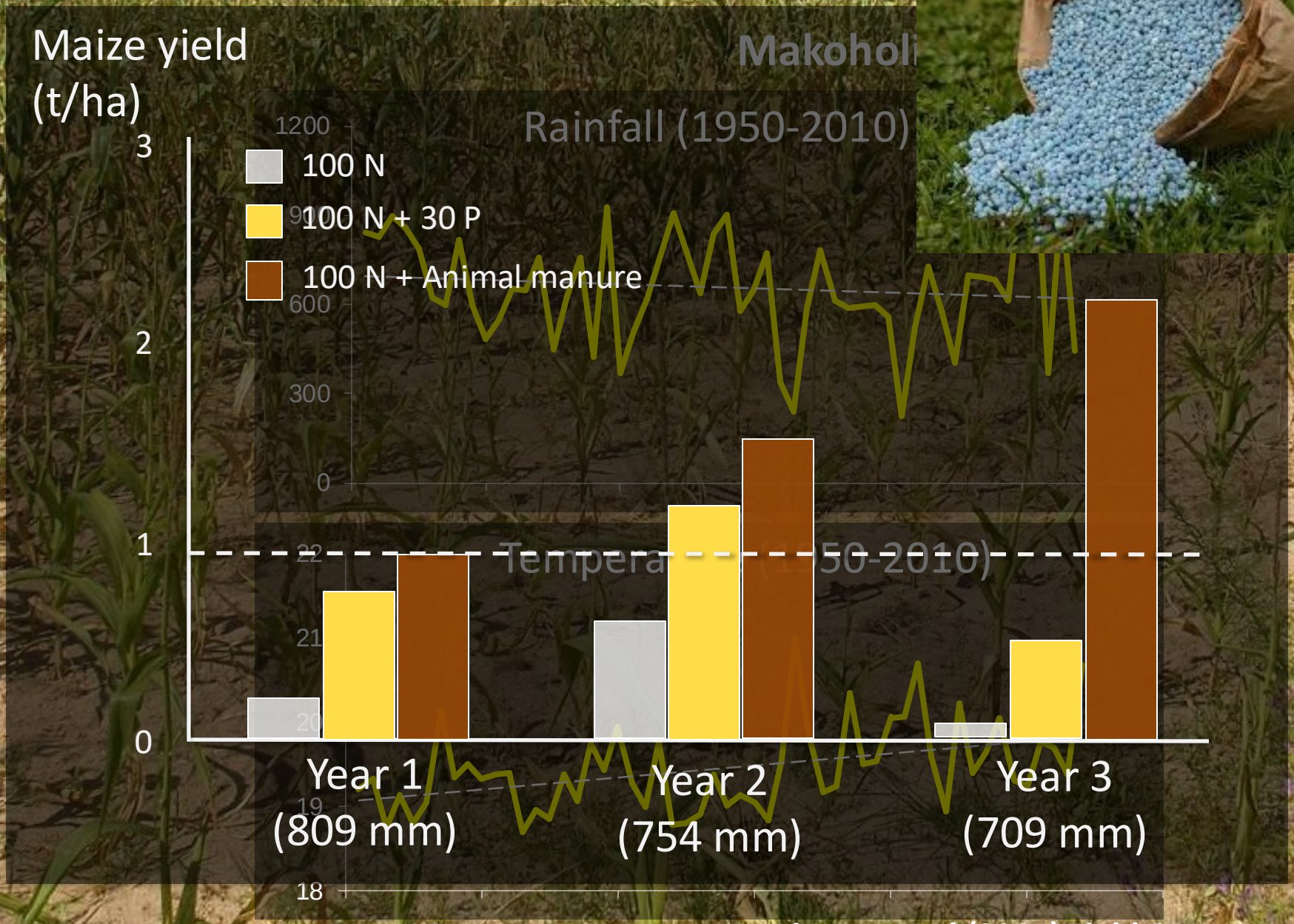
Variability in crop response to fertilizers (Tittonell, 2003; Vanlauwe et al.,2006)

perceptions of heterogeneity

ferential responses to ventions

ed to target technologies

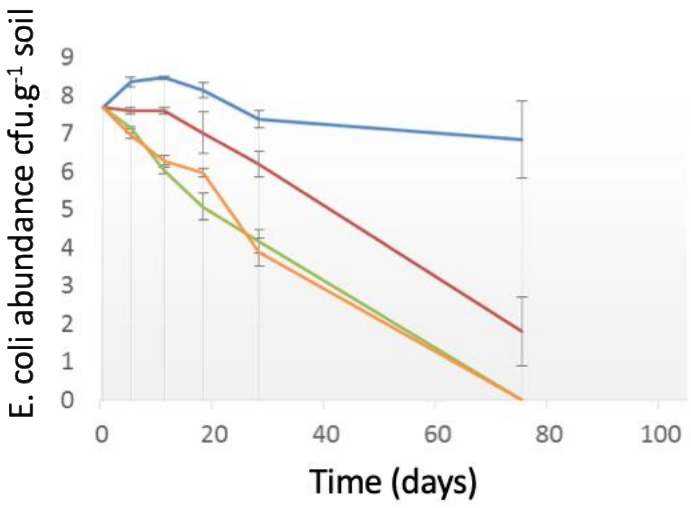
Climatic variability affects crop responsive

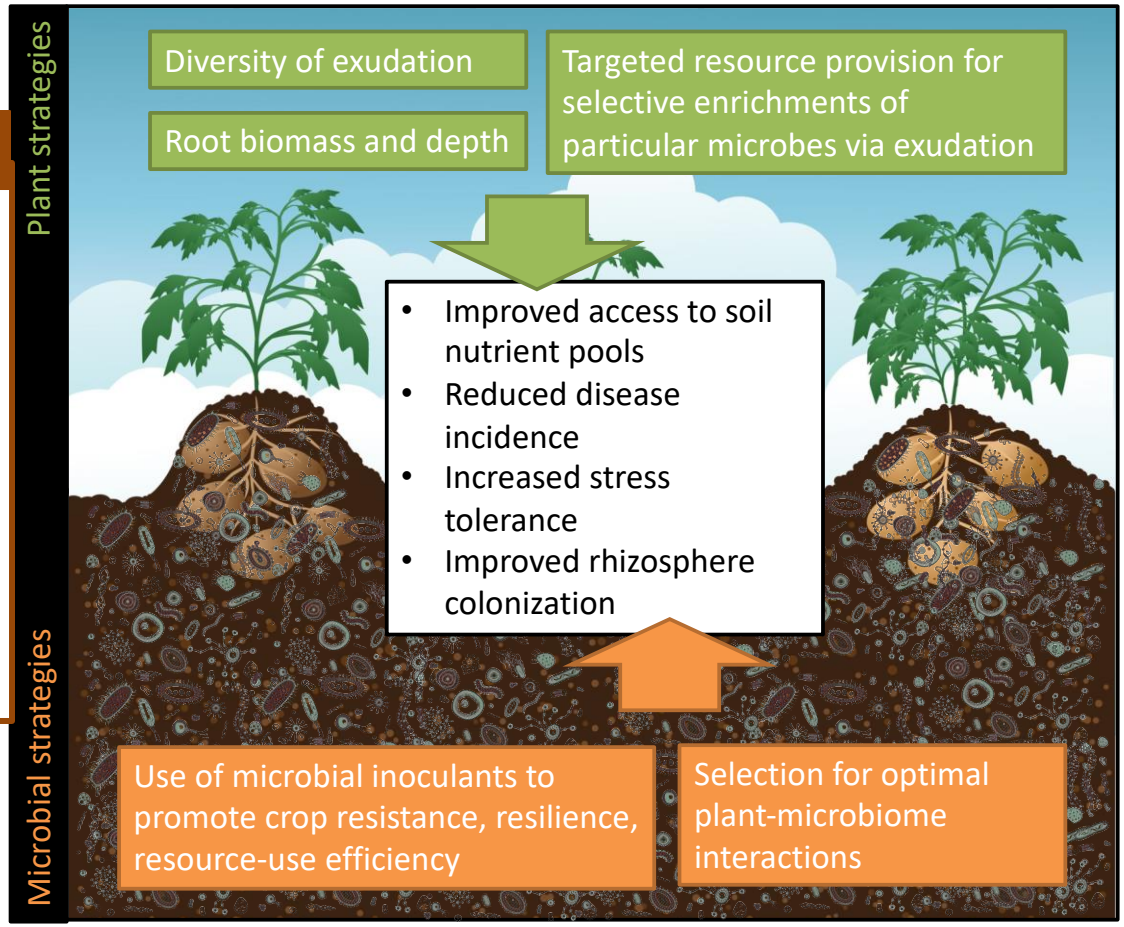


Zingore et al.(2007) Field Crops Research

The crop microbiome

Resistance against pathogens





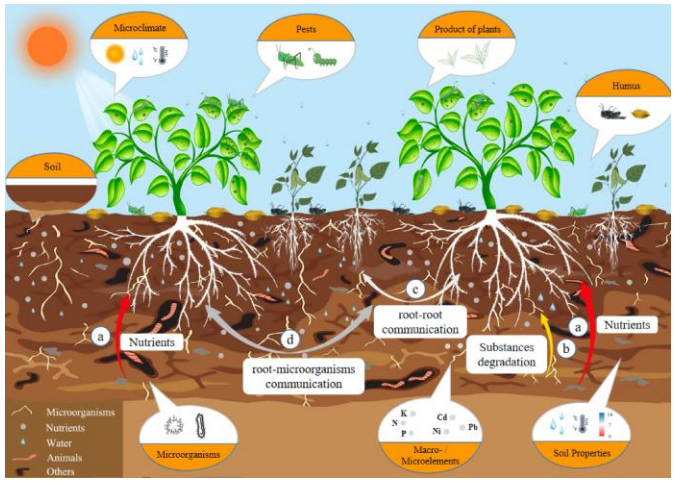
Salles et al, in prep

potatoMETAbiome

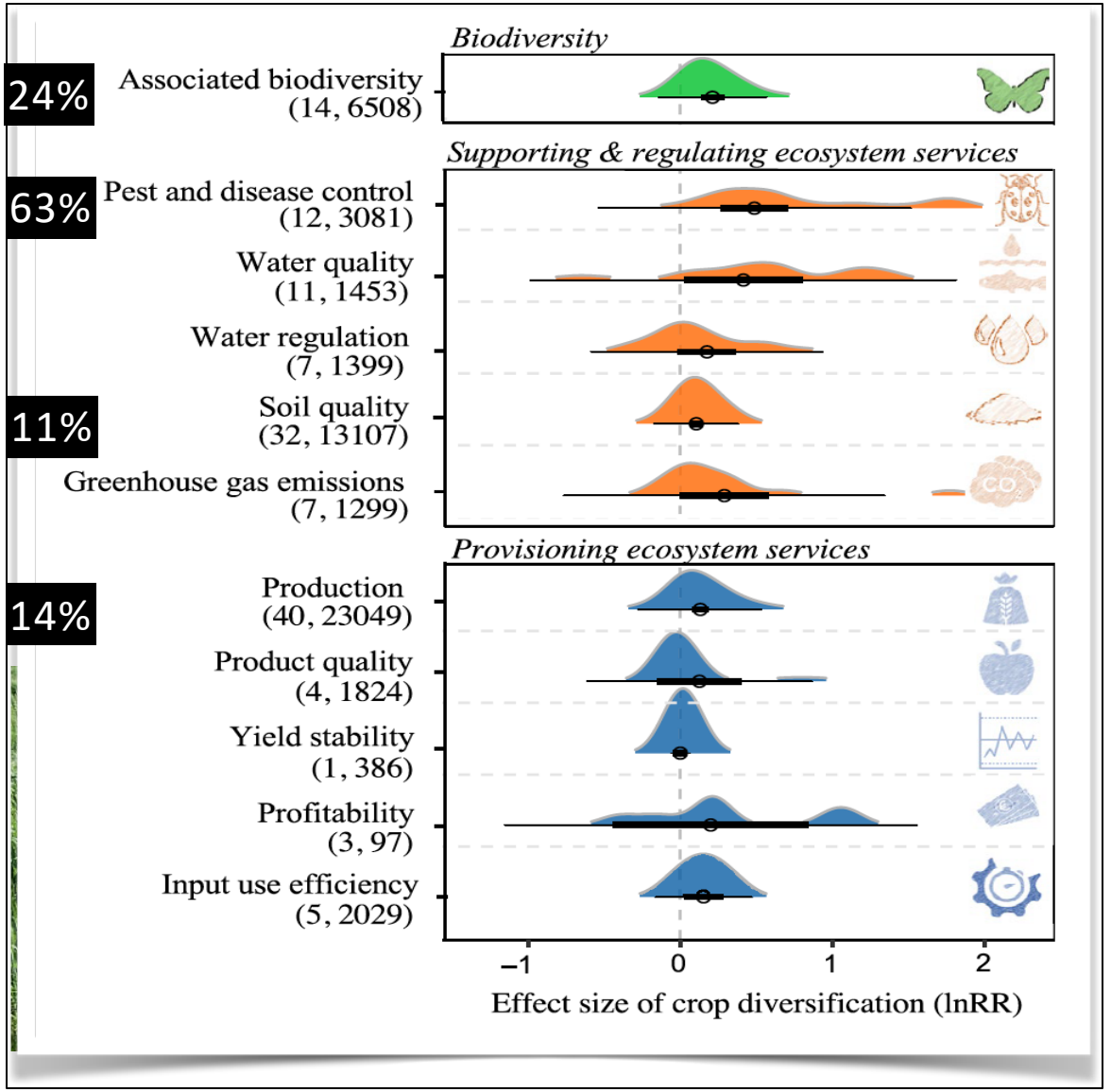
EUROPEAN RESEARCH AREA ON SUSTAINABLE CROP PRODUCTION

The ERA-Net Cofund SusCrop is funded by European Union's Horizon 2020 research and innovation programme under grant agreement No 771134

FACCEJPI SusCrop ERA-NET



Crop diversification

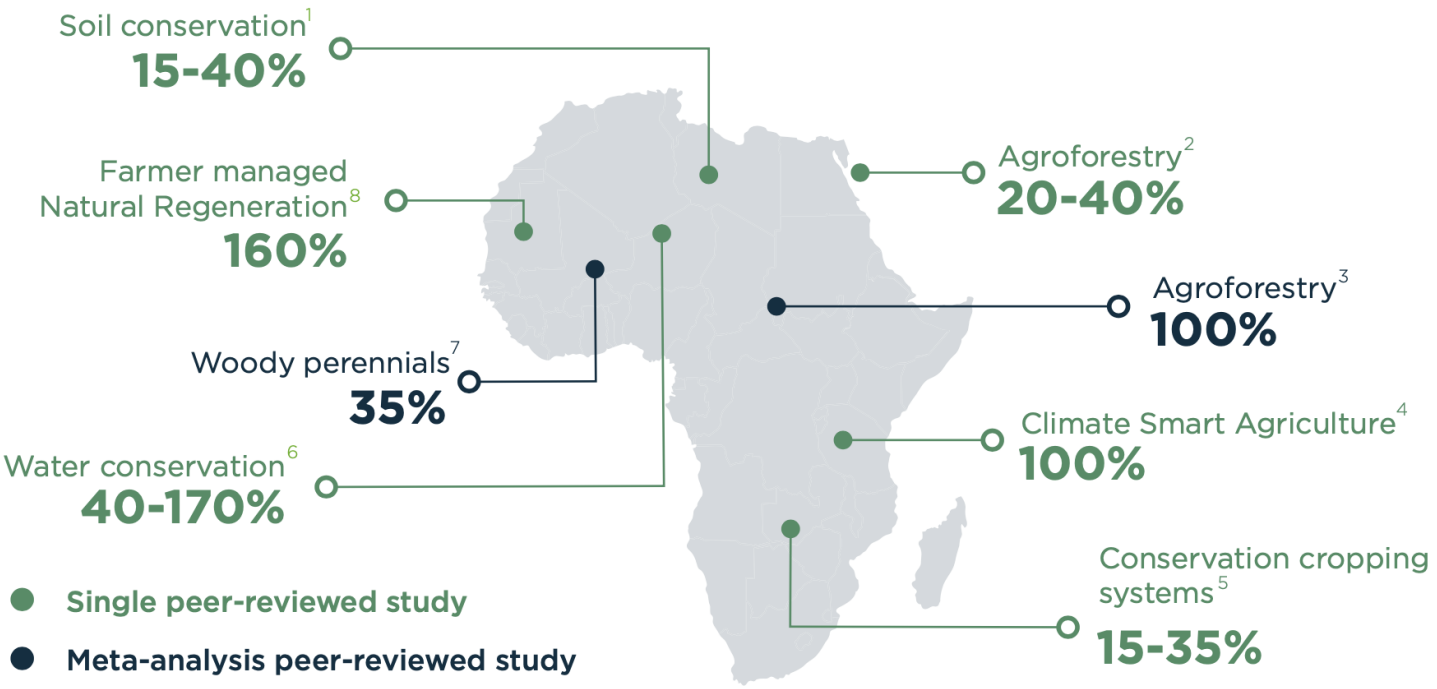


Beillouin et al 2021Global Change Biology

Is regenerative agriculture the same as agroecology?

Regenerative practices

Figure 1: Crop yield increase observed in several regenerative agriculture initiatives across sub-Saharan Africa

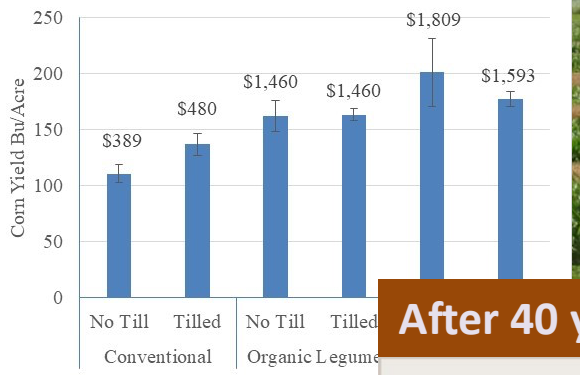


Note: Values in the figure are rounded values. 1. Ibrahim et al. (2015), 2. Fahmi et al. (2018), 3. Shem Kuyah et al. (2019), 4. Amadu et al. (2020), 3. Shem Kuyah et al. (2019)5. Thierfelder et al. (2015)., 6. Reij et al. (2010), 7. Félix et al. (2018), 8. Birch et al. (2016) Reij et al. (2010). Thierfelder et al. (2015).

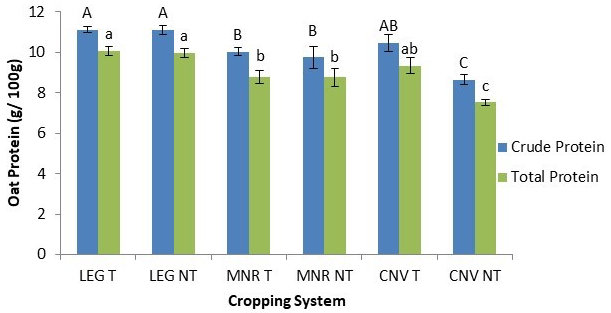
Evidence supporting regenerative agriculture?

Experimental data

Crop yields and gross margins (us$)



Crop nutritional density (g/100 g)



Soil organic matter (%)

Pesticide leaching (ppb)

After 40 years comparisons, regenerative organic systems:

ARE COMPETITIVE WITH CONVENTIONAL YIELDS
AFTER A 5-YEAR TRANSITION PERIOD

PRODUCE YIELDS UP TO **40% HIGHER**
IN TIMES OF DROUGHT

EARN 3-6X GREATER PROFITS
FOR FARMERS

LEACH NO TOXIC CHEMICALS
INTO WATERWAYS

USE 45% LESS ENERGY

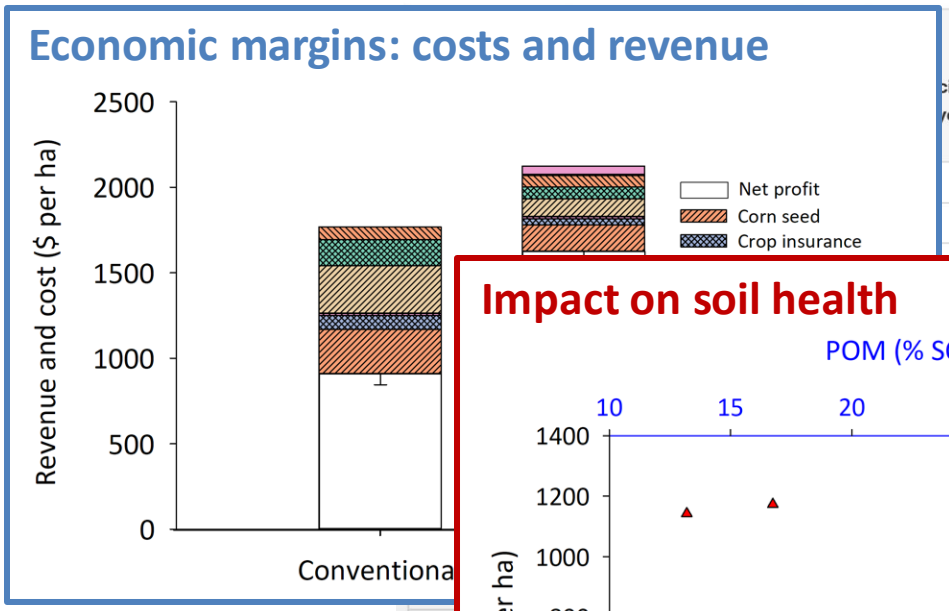
RELEASE 40% FEWER
CARBON EMISSIONS

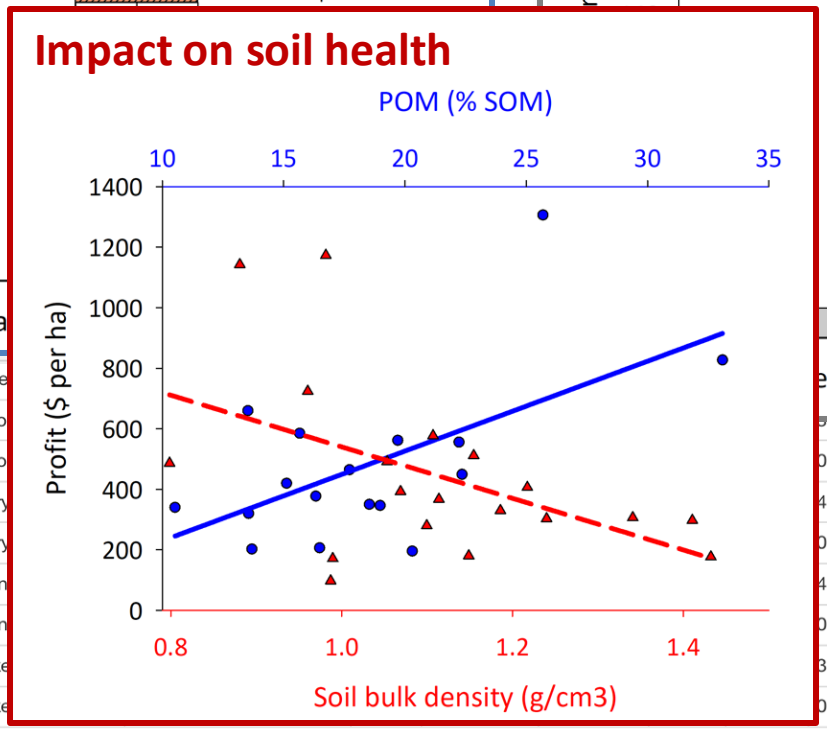
Regenerative organic witl
Regenerative organic witl
Conventional agriculture

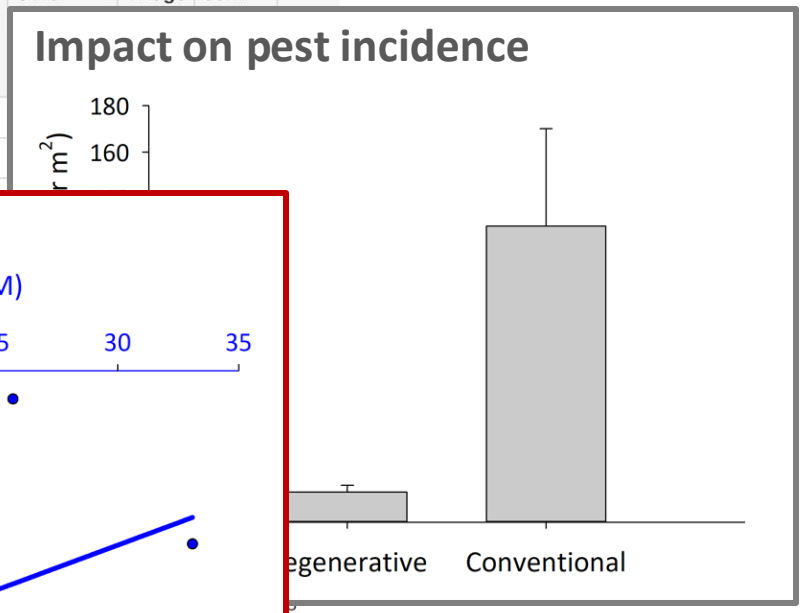
Rodale Institute - ania, 1981 - 2021

Evidence supporting regenerative agriculture?

On-farm data (Maize in USA)







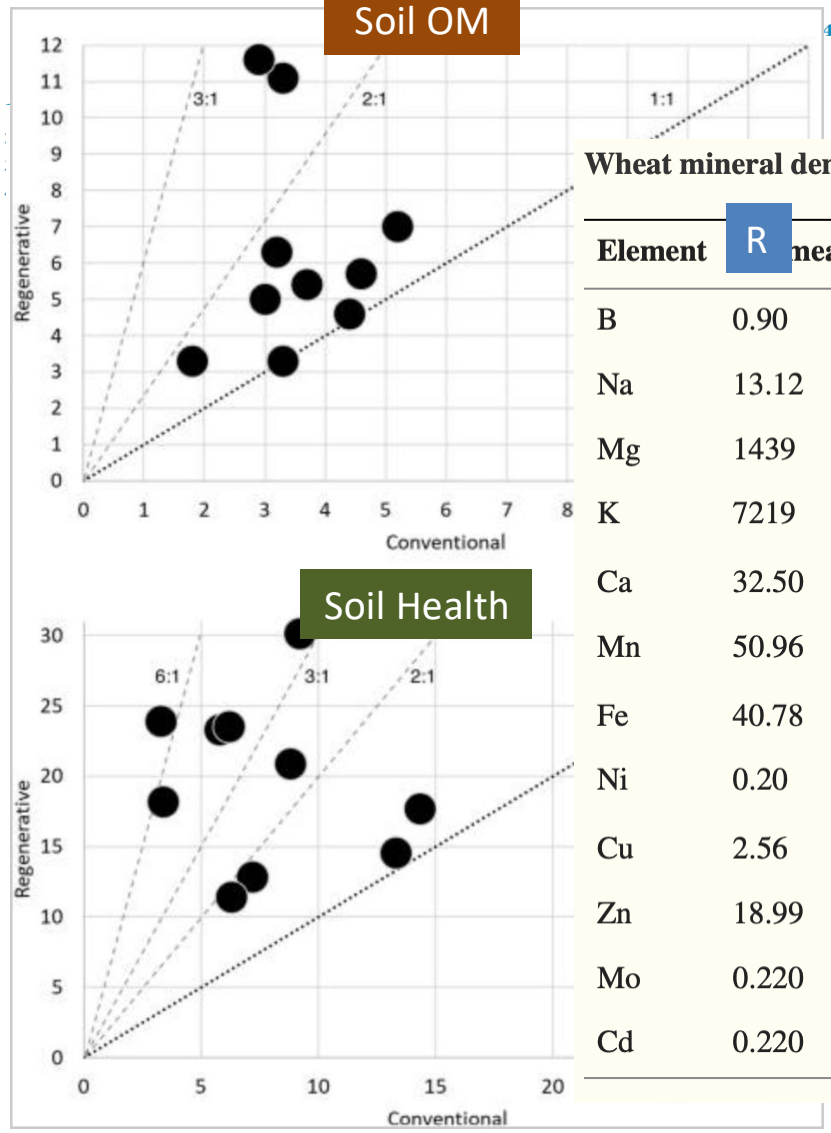
LaCanne and Lundgren (2018)

Table 1:
Trait matrix used to assign farms to regenerative or conventional corn production systems.
The composite rank scores are based on the number of regenerative practices used on a particular farm. Farms whose rank scores are in the top 50% of farms are considered regenerative (shaded rows); those with rank scores in the lower half are conventional (white rows). To aid interpretation, additional traits of each system could be included in enhanced trait matrices. Organic operations are indicated by an asterisk in the "Reference town" column.

DOI: 10.7717/peerj.4428/table-1

Soil health and nutrient density: preliminary comparison of regenerative and conventional farming

Soil OM



Crop nutrient concentration ratios (R:C)

Nutrient	All crops	Cabbage	Peas	Soy	Corn	Sorghum
Vitamin K	**1.34**	**1.41**	**1.57**	1.10	-	**1.38**

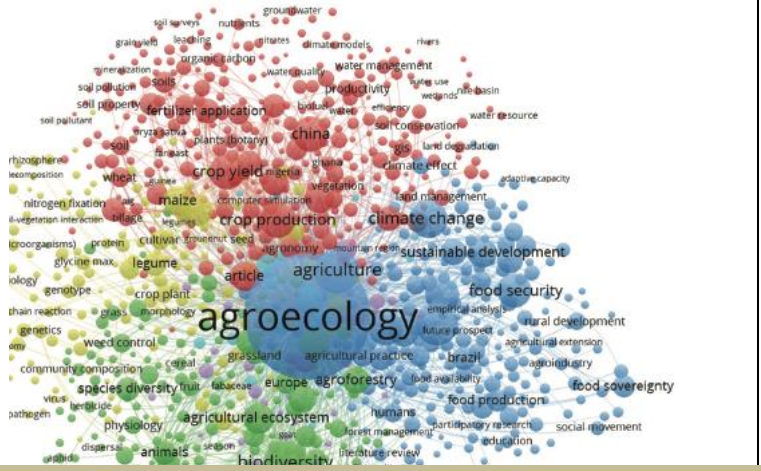
Wheat mineral density comparisons.

Element	R mean (ppm)	±Sd	C mean (ppm)	±Sd	CC/NC	*p* value
B	0.90	0.03	0.64	0.10	**1.41**	0.017
Na	13.12	0.69	13.20	3.13	0.99	0.064
Mg	1439	54	1112	181	**1.29**	0.040
K	7219	197	5750	1002	*1.26*	0.067
Ca	32.50	2.26	21.92	3.91	**1.48**	0.051
Mn	50.96	3.84	37.66	9.57	*1.35*	0.089
Fe	40.78	1.19	34.10	5.92	1.20	0.128
Ni	0.20	0.01	0.30	0.06	*0.67*	0.055
Cu	2.56	0.16	2.17	0.40	1.18	0.202
Zn	18.99	0.59	12.21	3.10	**1.56**	0.021
Mo	0.220	0.060	0.053	0.010	**4.15**	0.011
Cd	0.220	0.000	0.023	0.010	0.87	0.373

Montgomery DR, Biklé A, Archuleta R, Brown P, Jordan J. Soil health and nutrient density: preliminary comparison of regenerative and conventional farming. PeerJ. 2022 Jan 27;10:e12848. doi: 10.7717/peerj.12848. PMID: 35127297; PMCID: PMC8801175.

Agroecology	Philosophy RA	Development RA	Corporate RA
Science, practice, movement: social and ecological principles, landscape approaches, bottom-up, different sources of knowledge	RA as adopted by individuals or networks, based on philosophical principles, close to permaculture or biodynamic approaches	RA as promoted by development organisations, social and ecological principles, landscape approaches, often top-down, close to organic and low input farming	RA as proclaimed by enterprises, based on practical agronomic principles and corporate sustainability approaches, close to conservation agriculture
Diversity			
Efficiency*			
Recycling			
Resilience			
Synergy			
Human and social values			
Co-creation and sharing of knowledge			
Food culture and traditions			
Circular and solidarity economy			
Responsible governance			

analysis of the scientific literature



Top-10 sources after a Google search on 'Regenerative agriculture' in The Netherlands:

1. https://regenerationinternational.org
2. https://www.metabolic.nl
3. https://www.nrdc.org
4. https://ellenmacarthurfoundation.org
5. https://www.renature.co
6. https://www.unilever.com
7. https://www.earthday.org
8. https://www.nestle.com
9. https://www.cbf.org
10. https://www.cargill.com

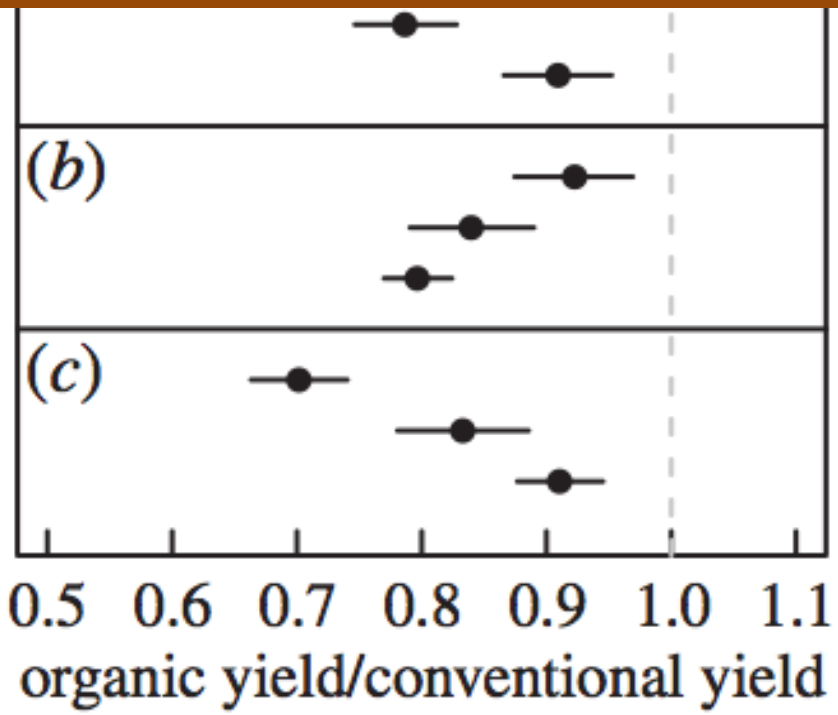
Revisited on 16 May 2022

Research investment gap between organic and conventional agriculture?

Example:

Dutch government = 4 million euro/year

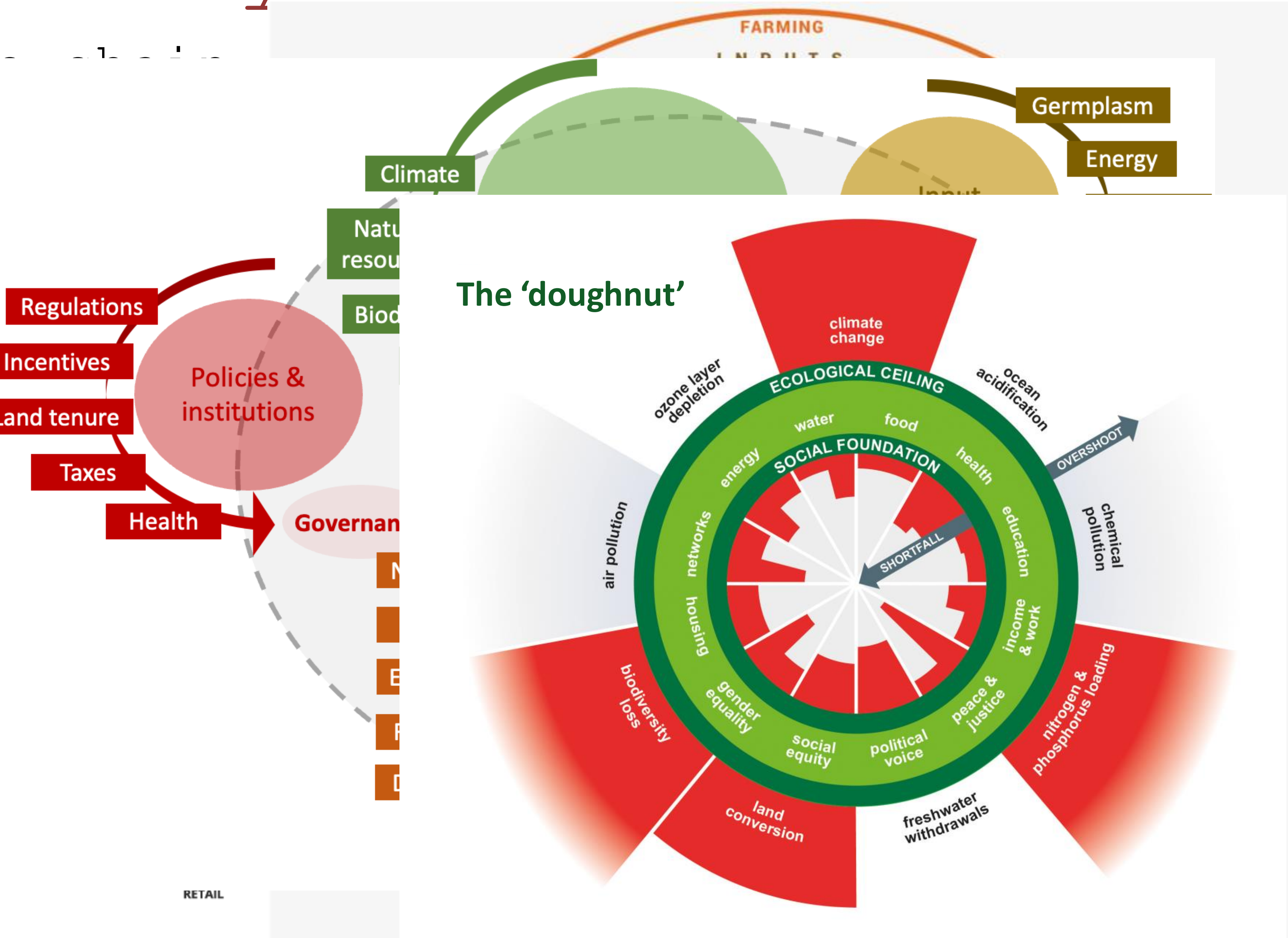
Monsanto = 980 million dollars/year (www.monsanto.com/investors)

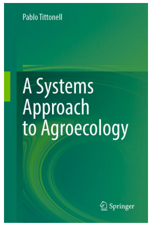


polyculture (18, 367)
organic polyculture only (17, 173)
more rotations in organic (14, 113)
no rotations (36, 178)
similar rotations (54, 670)
more conventional (33, 379)
more organic (15, 167)
similar (37, 300)

organic yield/conventional yield

food system





Tittonell, 2023. A Systems Approach to Agroecology, Springer-Nature, 393p.

Agroecology networks and COVID19 in Latin America

Resilience of food systems

What happens to the food system outcomes, i.e. food security & employment, under shocks and stressors?

High resilience capacity

Antifragility

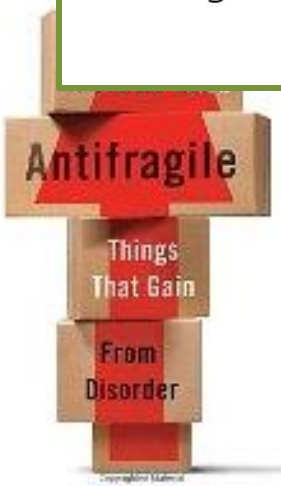
Elements that sustain food systems resilience & antifragility

Agency

Buffering

Connectivity

Diversity



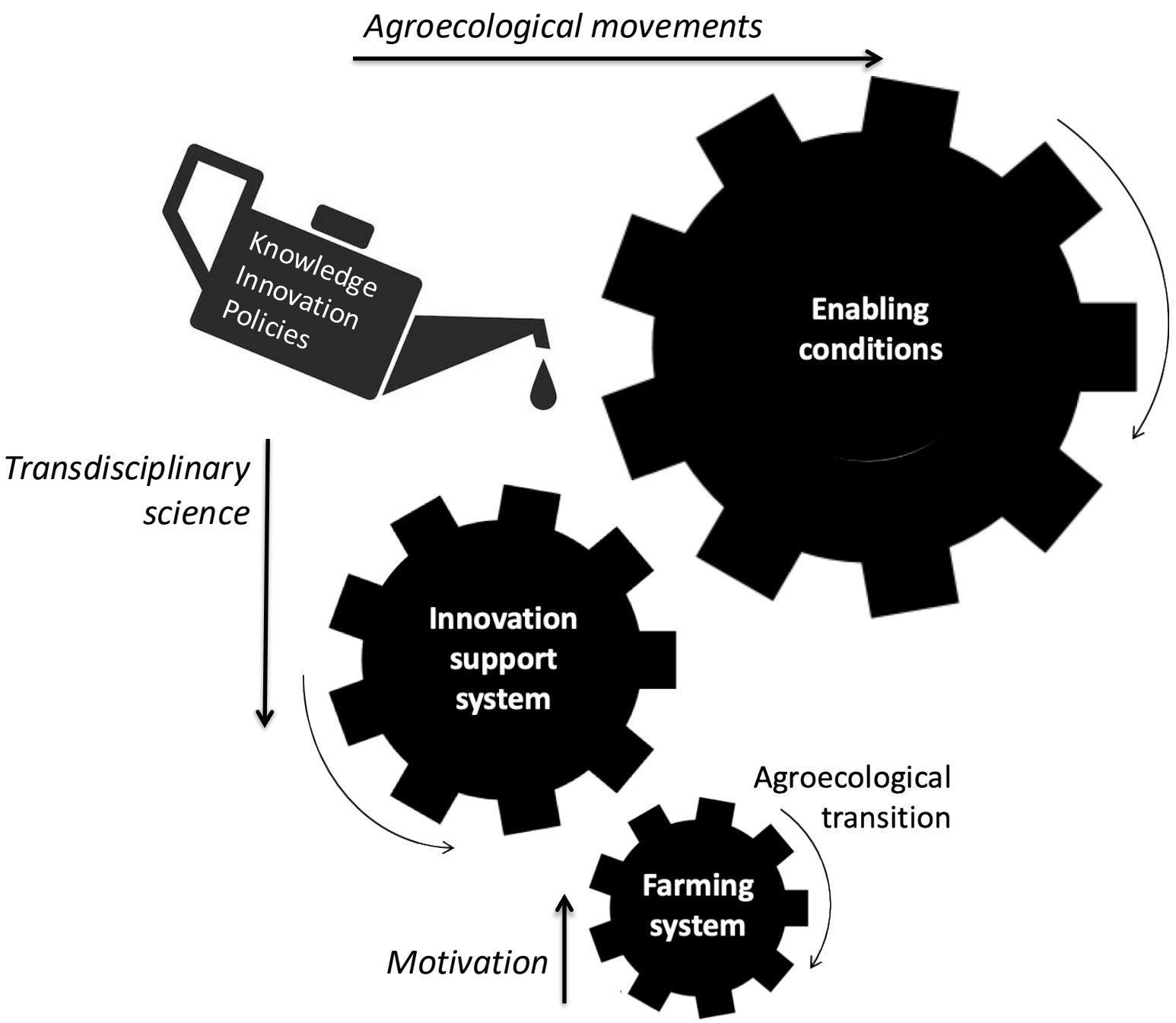
d resilience capacity

esilience capacity

Vulnerability

TIME

de Steenhuijsen Piters et al., 2021



Tittonell, 2023. A systems approach to agroecology