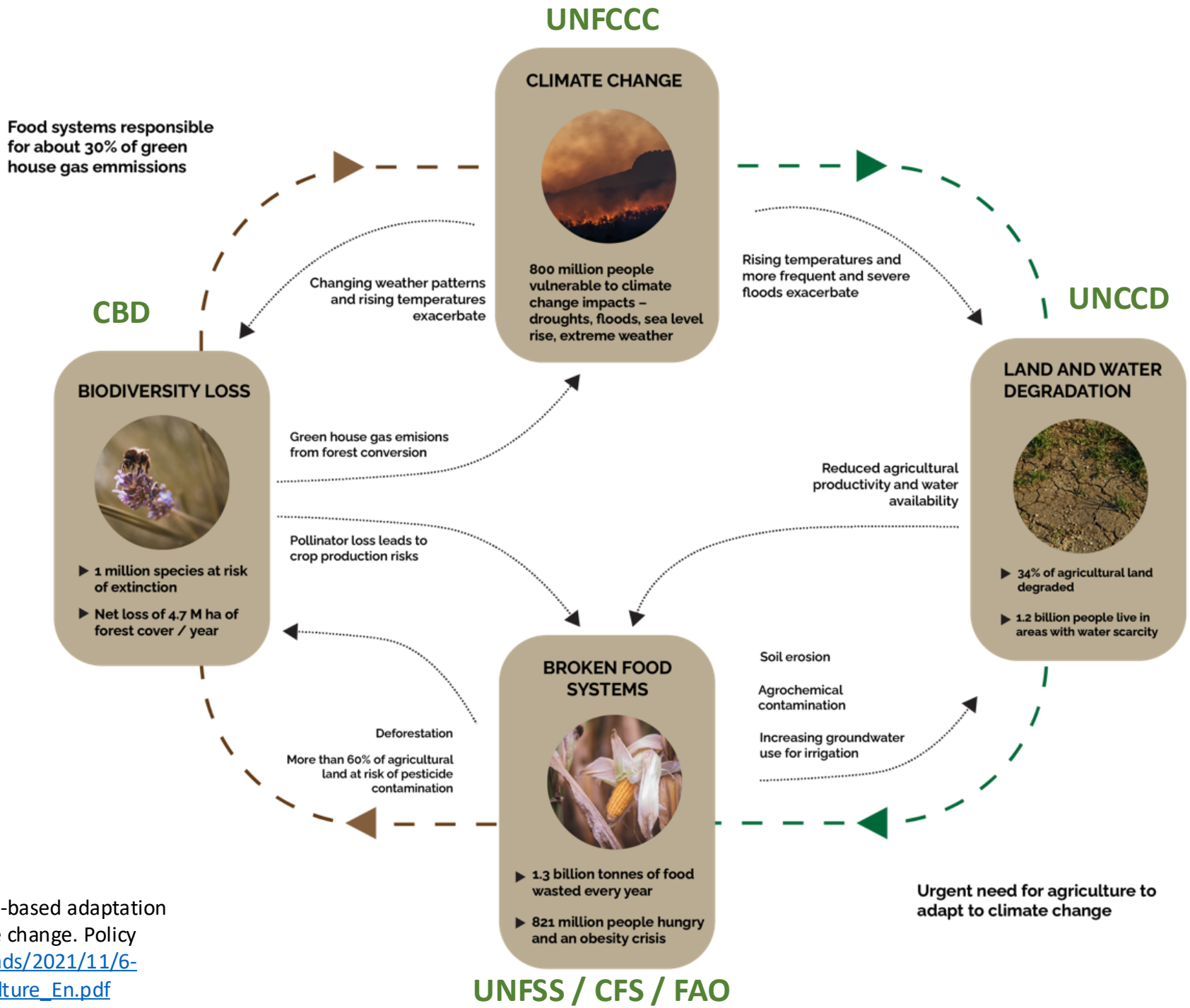
From agriculture to food consumption:
the many steps, challenges and opportunities around making food systems sustainable and equitable

Fergus Sinclair

Director of Agroecology CIFOR-ICRAF

Co-convenor Agroecology Transformative Partnership Platform (TPP)

Global challenges interact and their impacts are unequally distributed

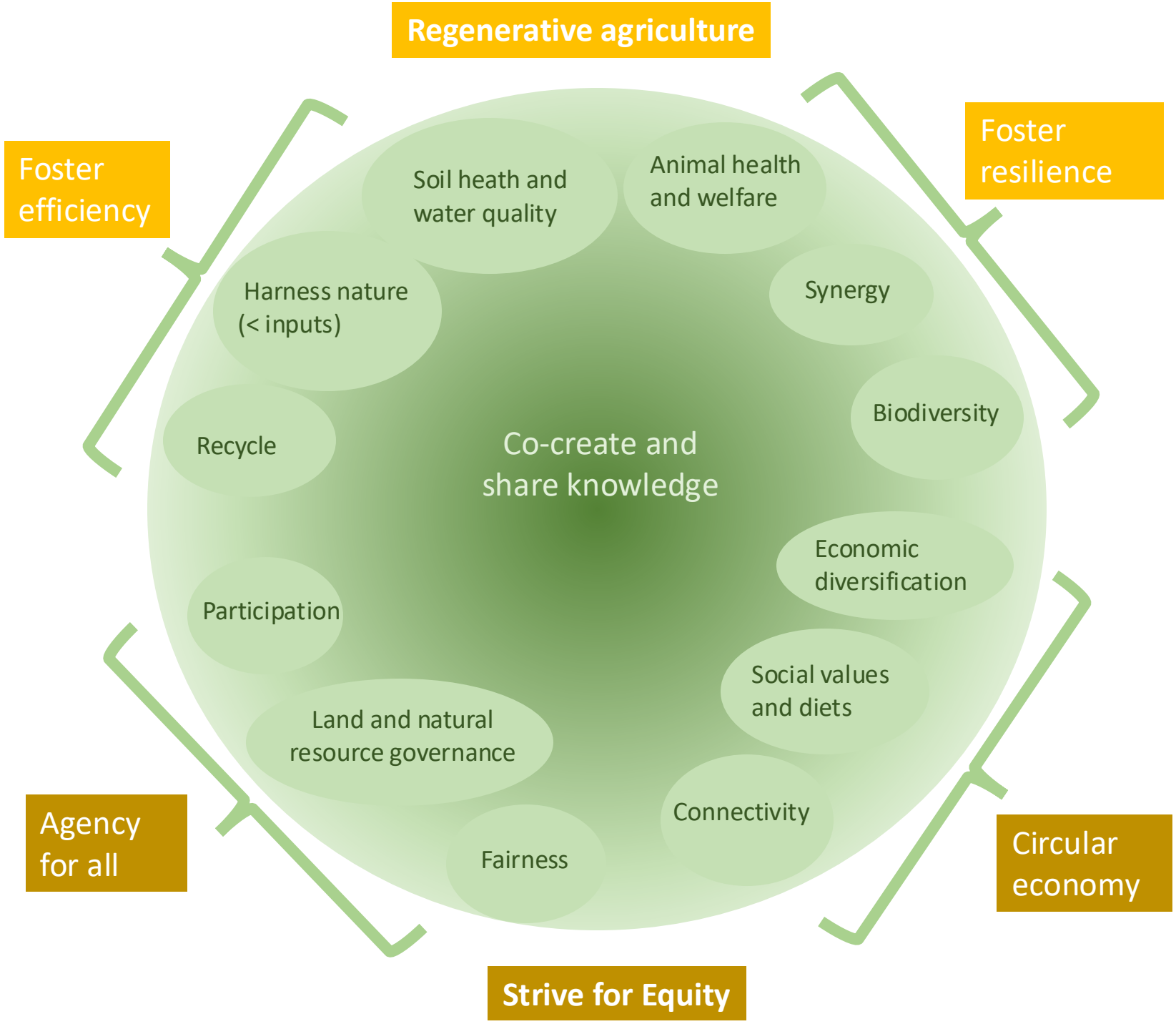


Systemic responses are required to adapt agricultural and food systems to the interrelated challenges

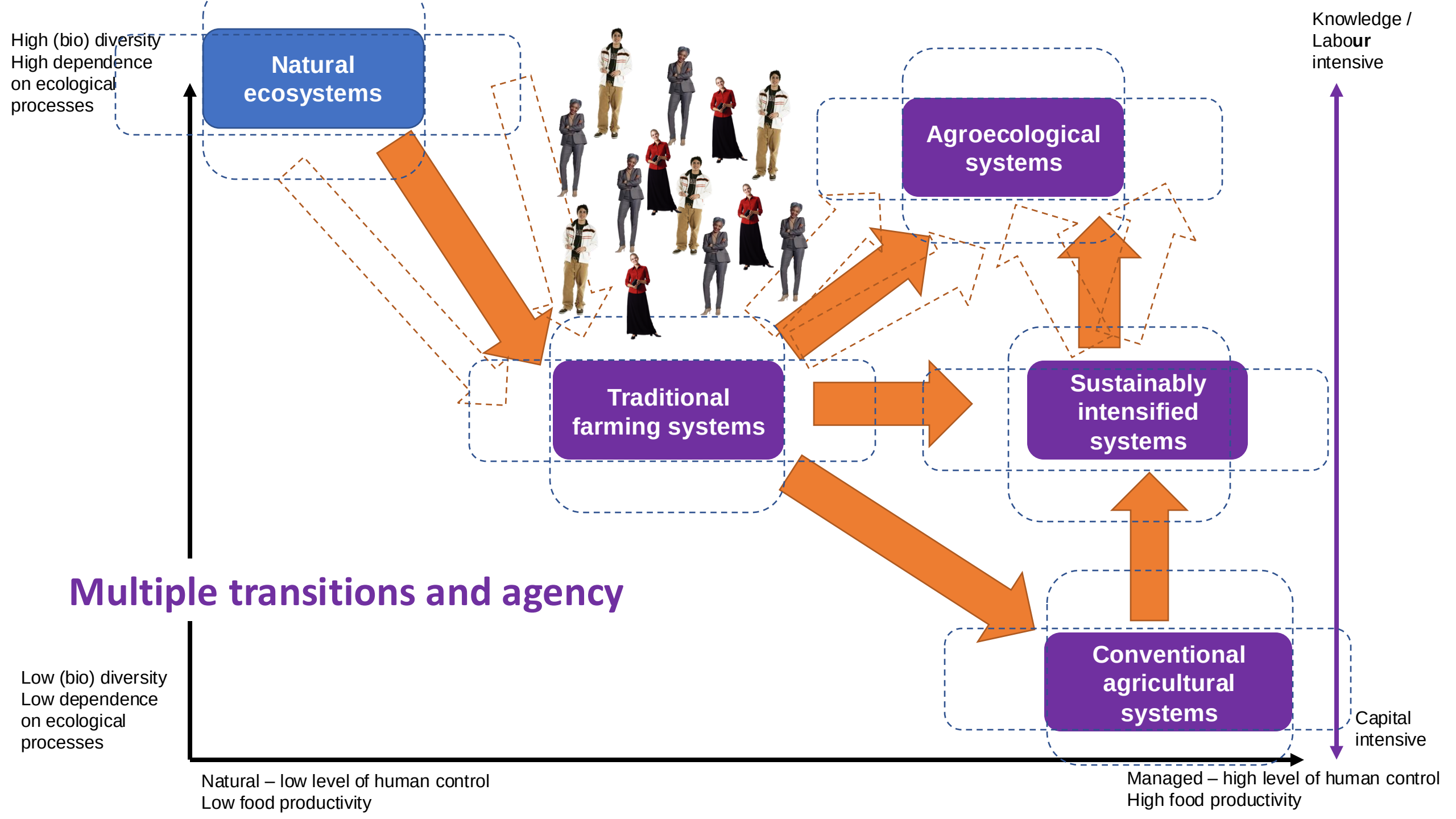
Weigelt, J, Sinclair F., Mikulcak, F and Lossak, H., 2021. Ecosystem-based adaptation in agriculture: how agroecology can contribute to tackling climate change. Policy Brief. https://www.globallandscapesforum.org/wp-content/uploads/2021/11/6-White-Paper_GLF-Climate-Ecosystem-based-adaptation-in-agriculture_En.pdf

Agroecology is an integrated response to global challenges.

It involves transforming food systems through local application of the 13 CFS, HLPE (2019) agroecological principles

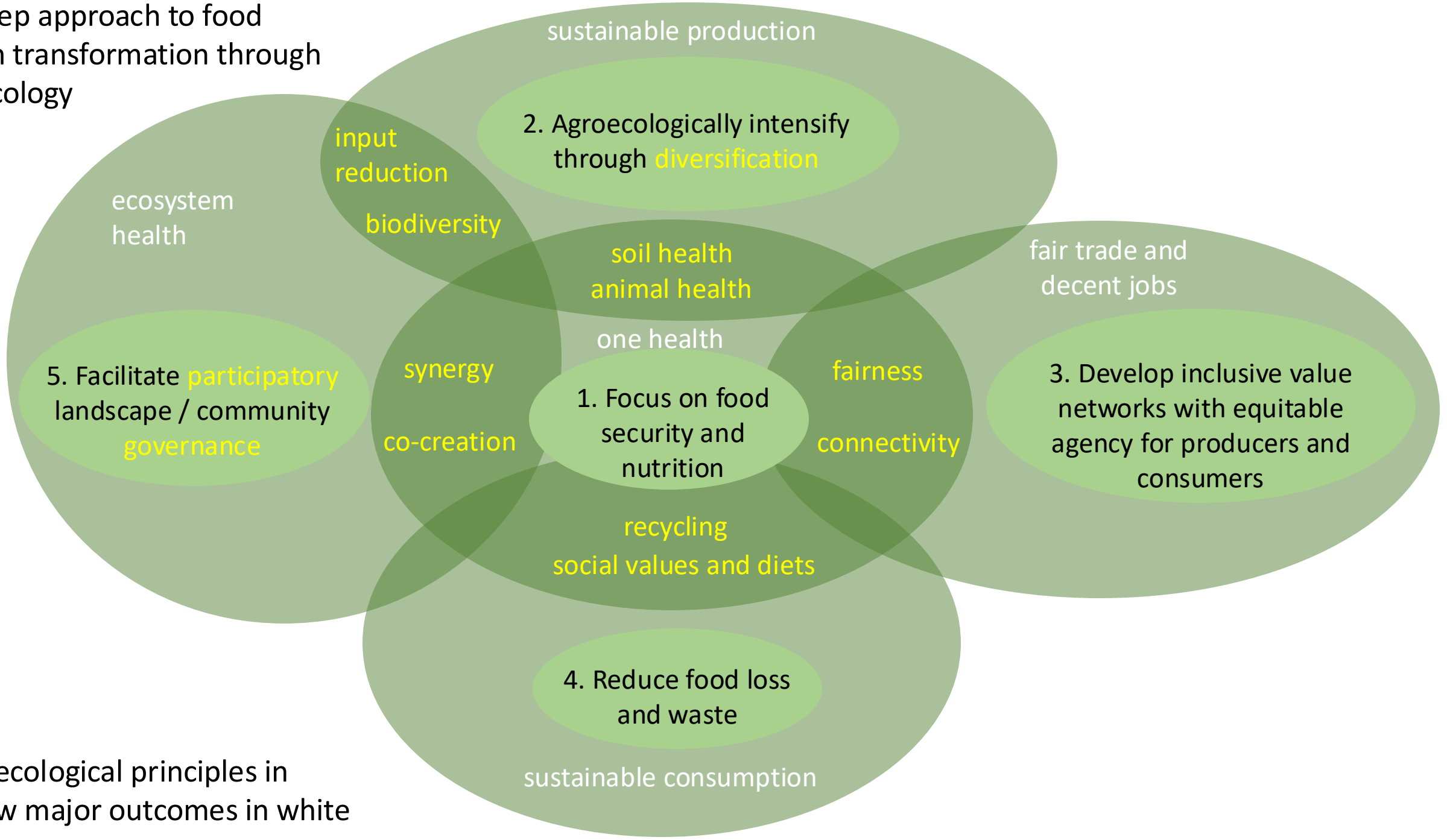


Wezel A, Gemmill Herren B, Bezner Kerr R, Barrios E, Gonçalves ALR and Sinclair F (2020). Agroecological principles and elements and their implications for transitioning to sustainable food systems. A review. *Agronomy for Sustainable Development* 40: 40 13pp. https://doi.org/10.1007/s13593-020-00646-z


High (bio) diversity
High dependence on ecological processes
Natural ecosystems
Knowledge / Labour intensive
Agroecological systems
Traditional farming systems
Sustainably intensified systems
Conventional agricultural systems
Multiple transitions and agency
Low (bio) diversity
Low dependence on ecological processes
Capital intensive
Natural – low level of human control
Low food productivity
Managed – high level of human control
High food productivity

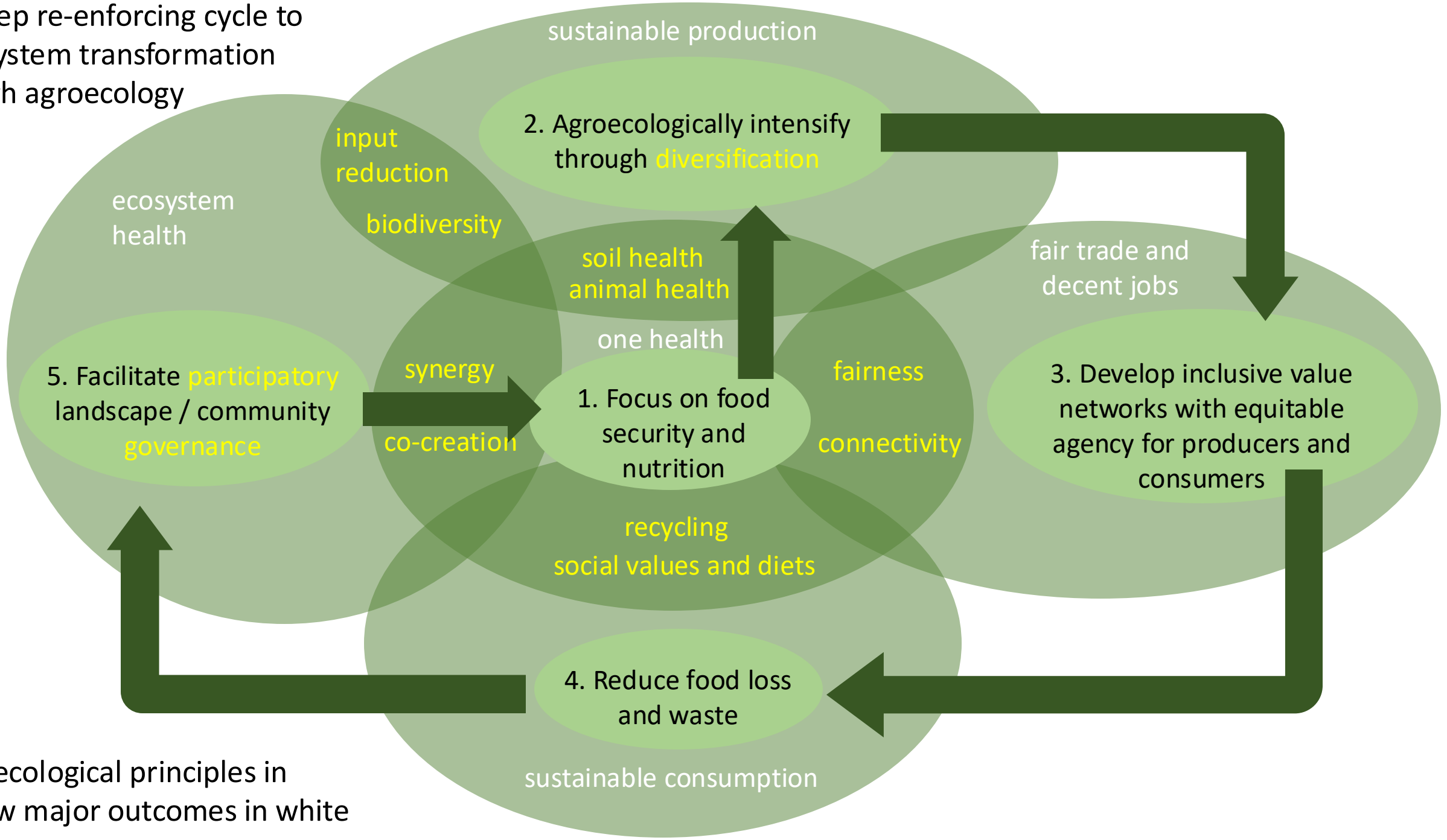
Transformation of whole food systems:
from farm to flush

Five step approach to food system transformation through agroecology



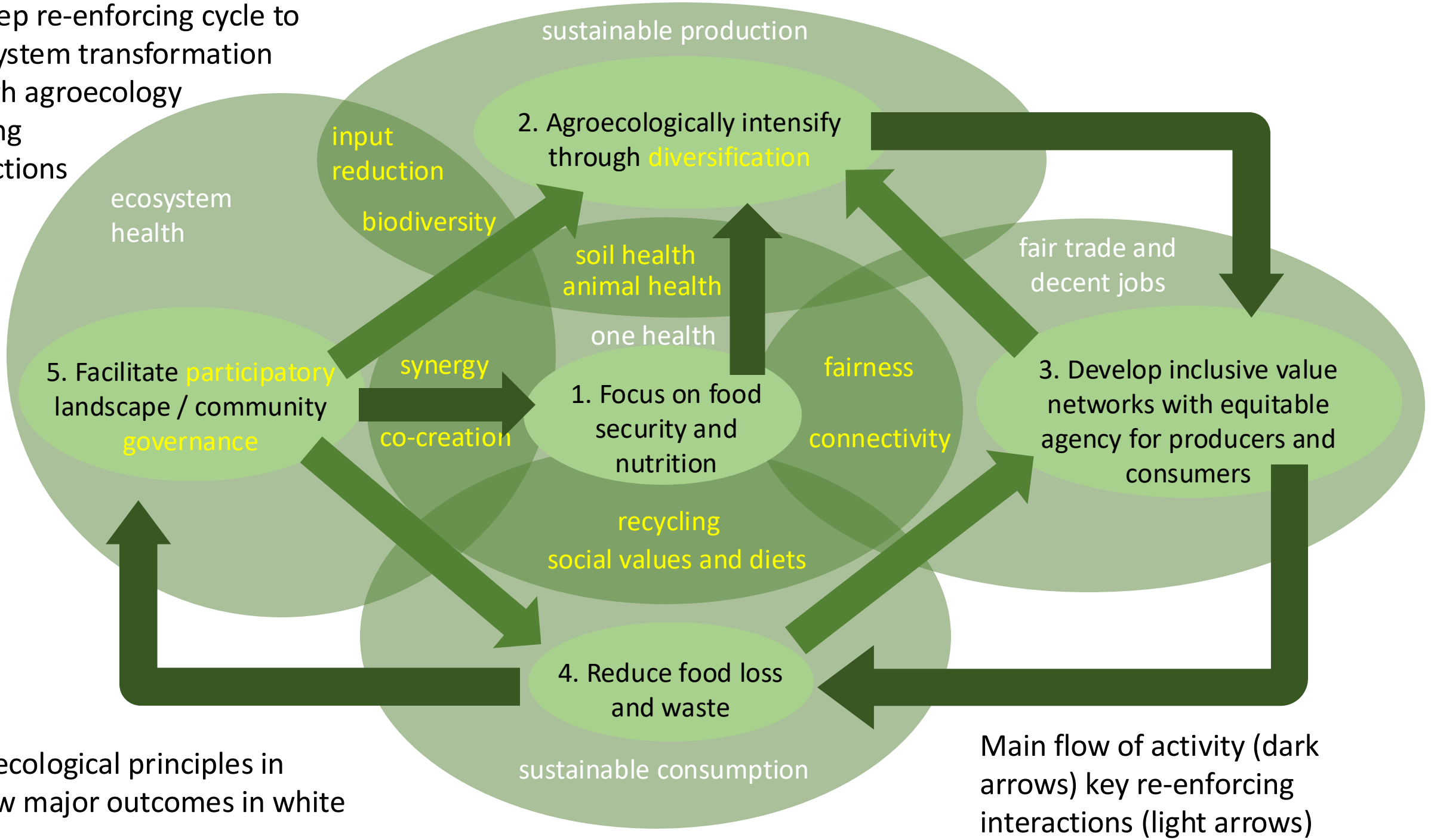
Agroecological principles in yellow major outcomes in white

Five step re-enforcing cycle to food system transformation through agroecology



Agroecological principles in yellow major outcomes in white

Five step re-enforcing cycle to food system transformation through agroecology showing interactions

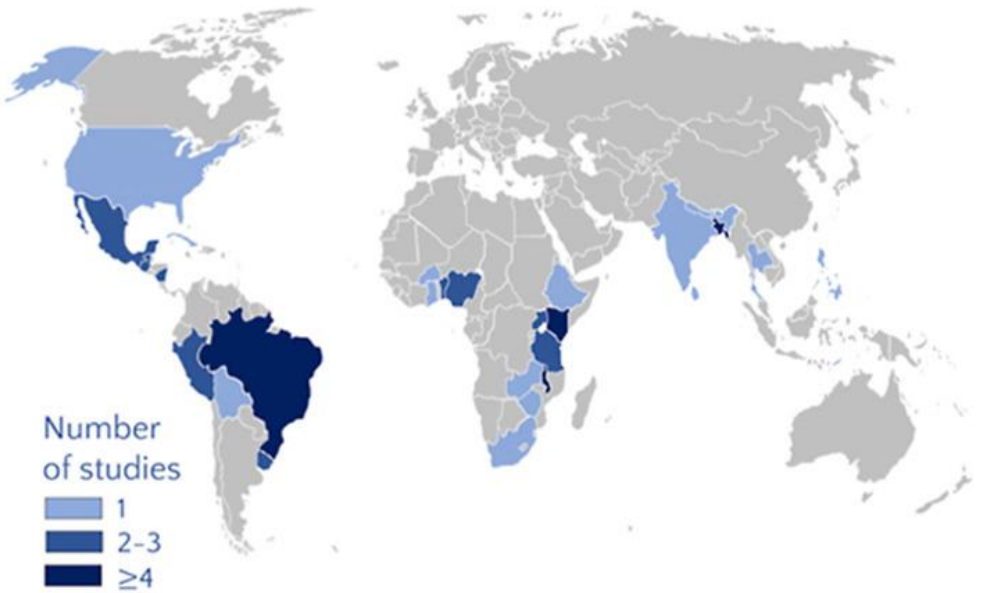


Agroecological principles in yellow major outcomes in white

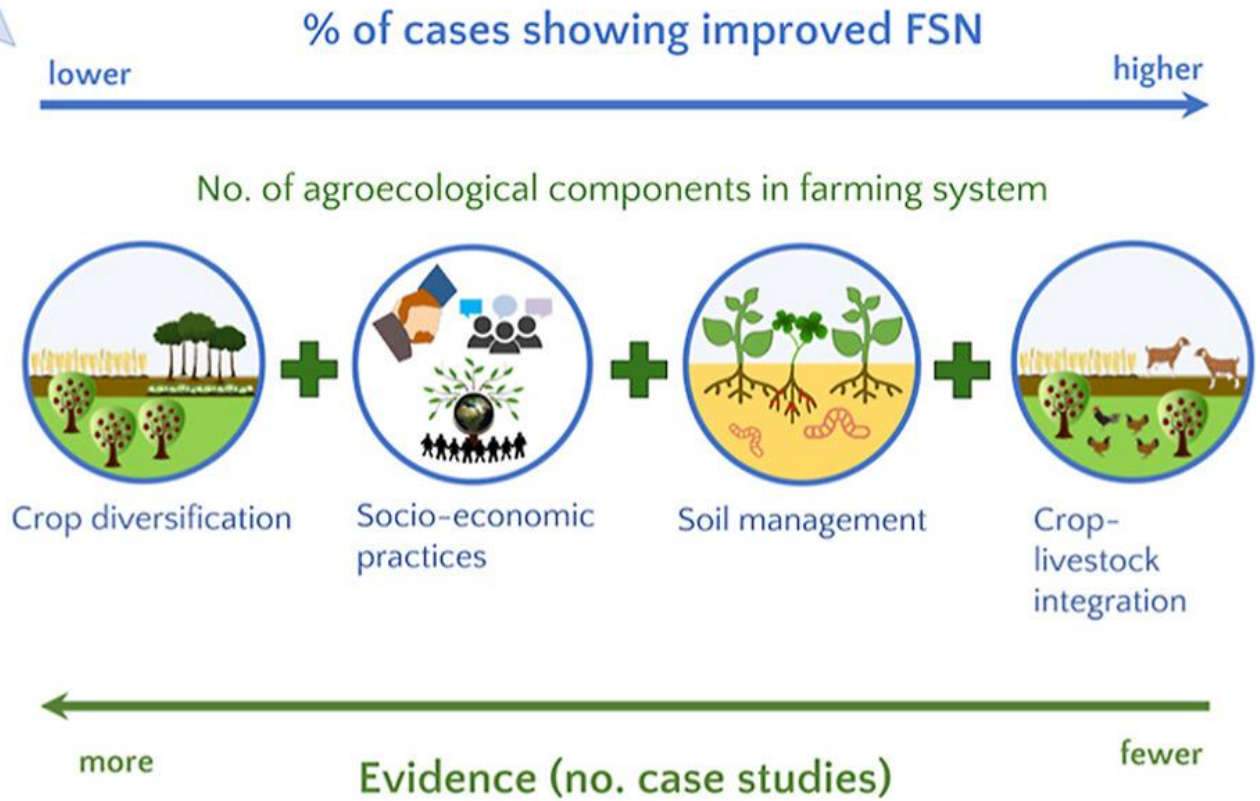
Main flow of activity (dark arrows) key re-enforcing interactions (light arrows)

How does agroecology influence Food Security and Nutrition (FSN)?

78% of studies found evidence of a positive relationship between agroecology and FSN.



55 case studies



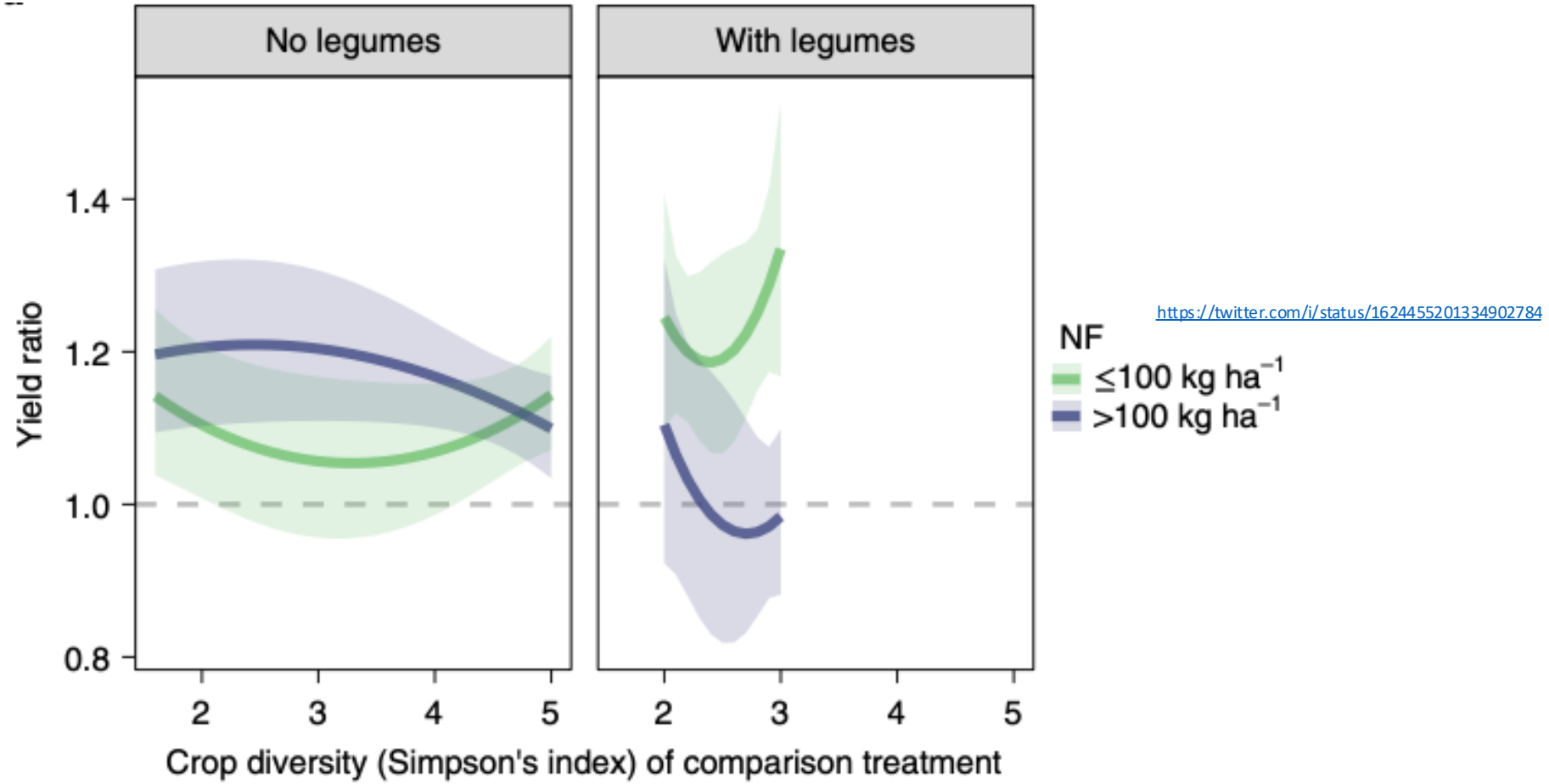
A higher proportion of studies on more complex agroecological approaches found positive FSN outcomes, albeit with a smaller number of studies for comparison.

Bezner Kerr et al., 2021. Can agroecology improve food security and nutrition? A review. *Global food security* 29: 100540
https://www.sciencedirect.com/science/article/abs/pii/S221191242100050X

Diversity and productivity go hand in hand

Crop diversification with legumes substitutes for nitrogen fertiliser on monocultures

Metanalysis of 30 long-term trials (each with at least 9 years data) (>25,000 data points).

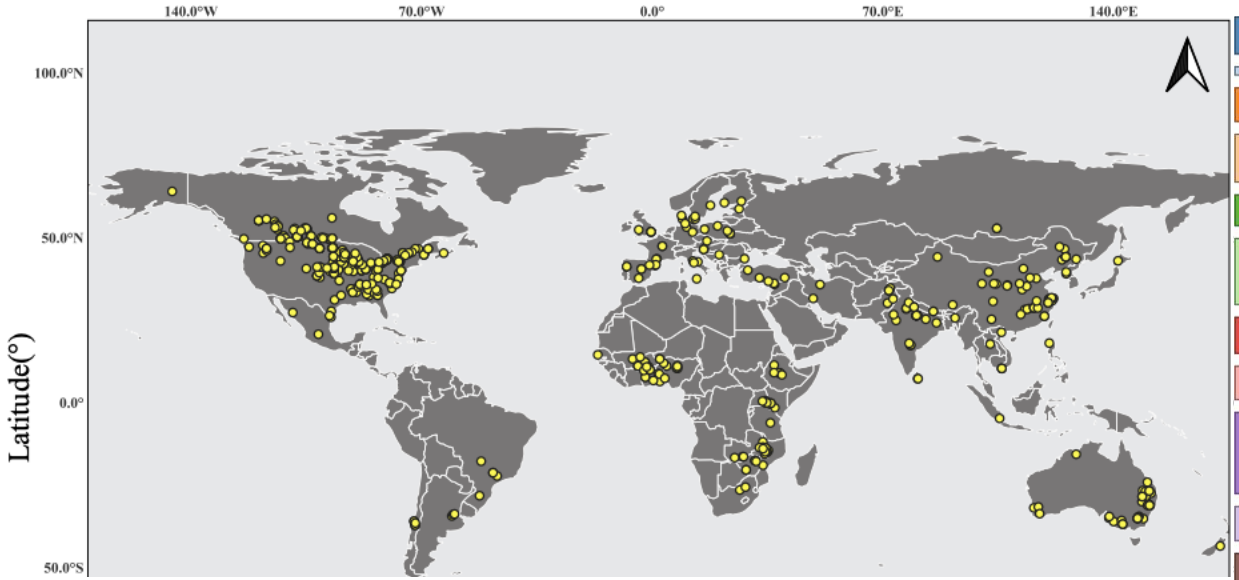


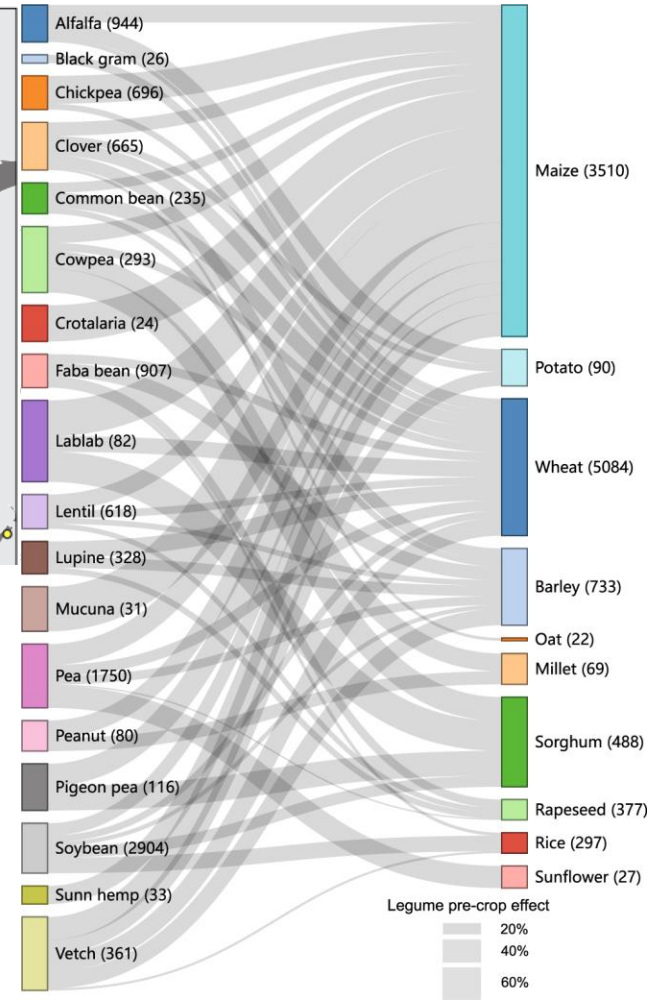
https://twitter.com/i/status/1624455201334902784

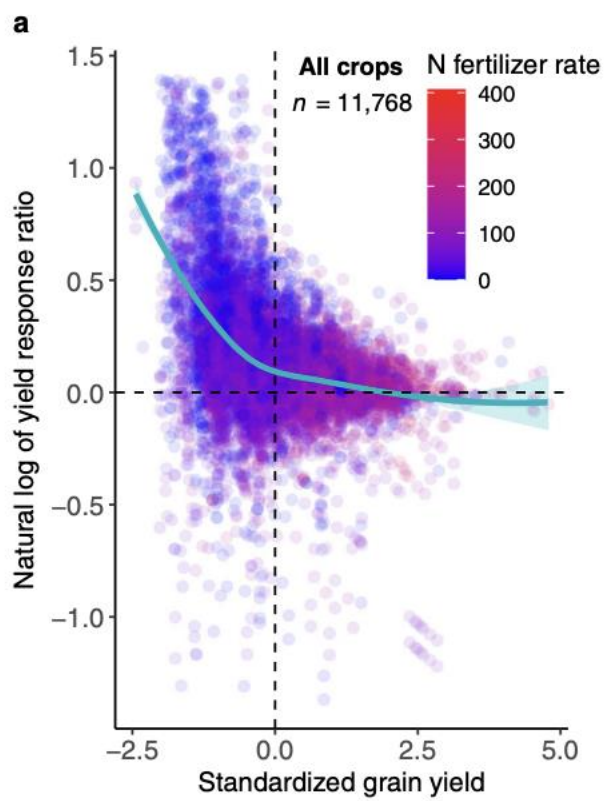
MacLaren, C et al., 2022. Long-term evidence for ecological intensification as a pathway to sustainable agriculture. *Nature Sustainability*. https://www.nature.com/articles/s41893-022-00911-x

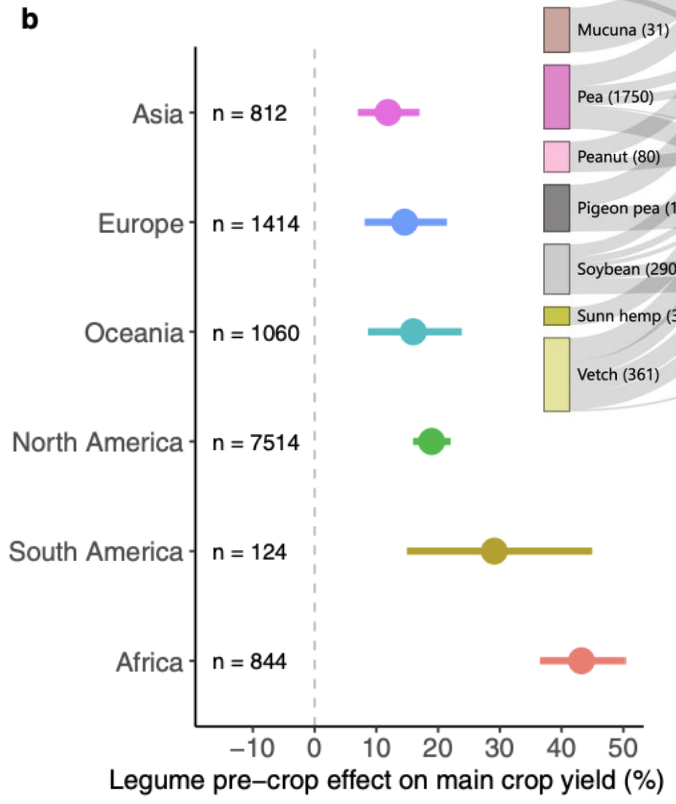
Global metanalysis of 11,768 yield observations from 462 field experiments comparing legume-based and non-legume cropping systems show that legumes enhanced main crop yield by 20% but declined with N fertilizer application (showing a substitution effect).

Zhao, J., Chen, J., Beillouin, D. *et al.* Global systematic review with meta-analysis reveals yield advantage of legume-based rotations and its drivers. *Nature Communications* **13**, 4926 (2022). https://doi.org/10.1038/s41467-022-32464-0



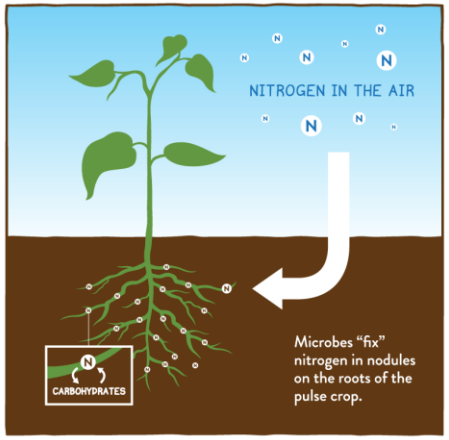






What is the most equitable and effective technology to fix nitrogen?

Empower smallholder farmers



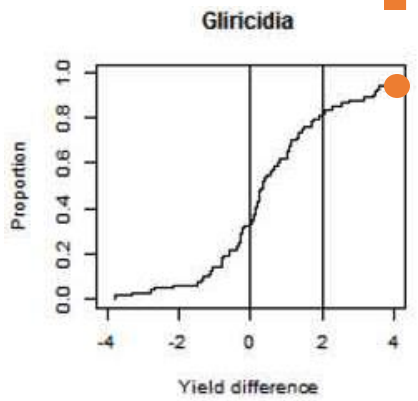
Citizen science

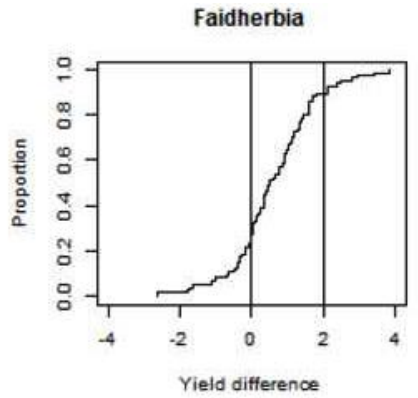
Centrally owned and produced, derived from fossil fuel use - high green house gas emissions, distribution costs and challenges, cost and risk to farmers (and governments where subsidized), non-resilient at farm and often national levels, high losses (leakage / pollution) BUT **SIMPLE**

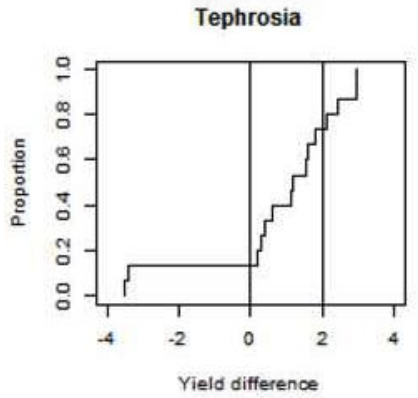
Distributed ownership by millions of farmers, derived from solar energy, lower cost and risk to farmers, more resilient at farm and often national levels, less leakage / pollution BUT **COMPLEX and KNOWLEDGE INTENSIVE – REQUIRES SYSTEM CHANGE – SUPPORT for LOCAL INNOVATION** (co-creation and sharing of knowledge)

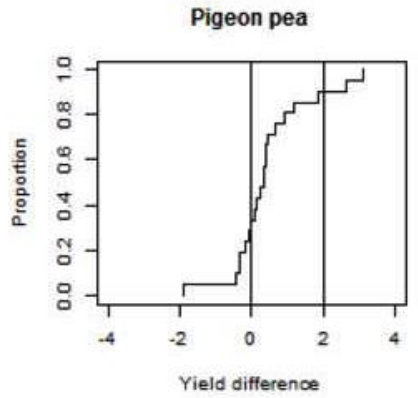
Fertiliser trees – Malawi

the importance of options by context (OxC)









Douglas Tana in Malawi - incorporating gliricidia in his 0.1 ha field increased annual maize yield from five to between 14 and 18 bags (an average of 8 t ha^{-1}) and enabled him to buy a cow that he feeds on a mixture of wilted gliricidia leaves and maize bran giving at least 8 l of milk a day (up to 15 l). Before planting maize he cuts the gliricidia, strips the leaves and incorporates them in the soil (he places them in a ridge and then covers them), the stems are retained for firewood. The maize yield from his 0.1 ha represents annual consumption of nearly 6 people, based on a mean daily per capita consumption rate of 382 g (Ecker and Qaim, 2011).

Ecker, O., and M.Qaim. 2011. "Analyzing Nutritional Impacts of Policies: An Empirical Study for Malawi." World Development, 39(3): 412–428.

Mazunda J and Droppelmann, K (2012). Maize consumption estimation and dietary diversity assessment methods in Malawi. IFPRI, MASSP Policy Note. https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/126849/filename/127060.pdf

Coe, R., Njoloma, J. and Sinclair, F. (2019). Loading the dice in favour of the farmer: reducing the risk of adopting agronomic innovations. Experimental Agriculture 55 (SI): 67–83.

Coe R, Njoloma J, Sinclair F (2019) To control or not to control: how do we learn more about how agronomic innovations perform on farms? *Experimental Agriculture* 55 (SI): 303-309.

Sinclair, F and Coe R (2019). The options by context approach: a paradigm shift in agronomy. *Experimental Agriculture* 55 (S1): 1–13.

Science

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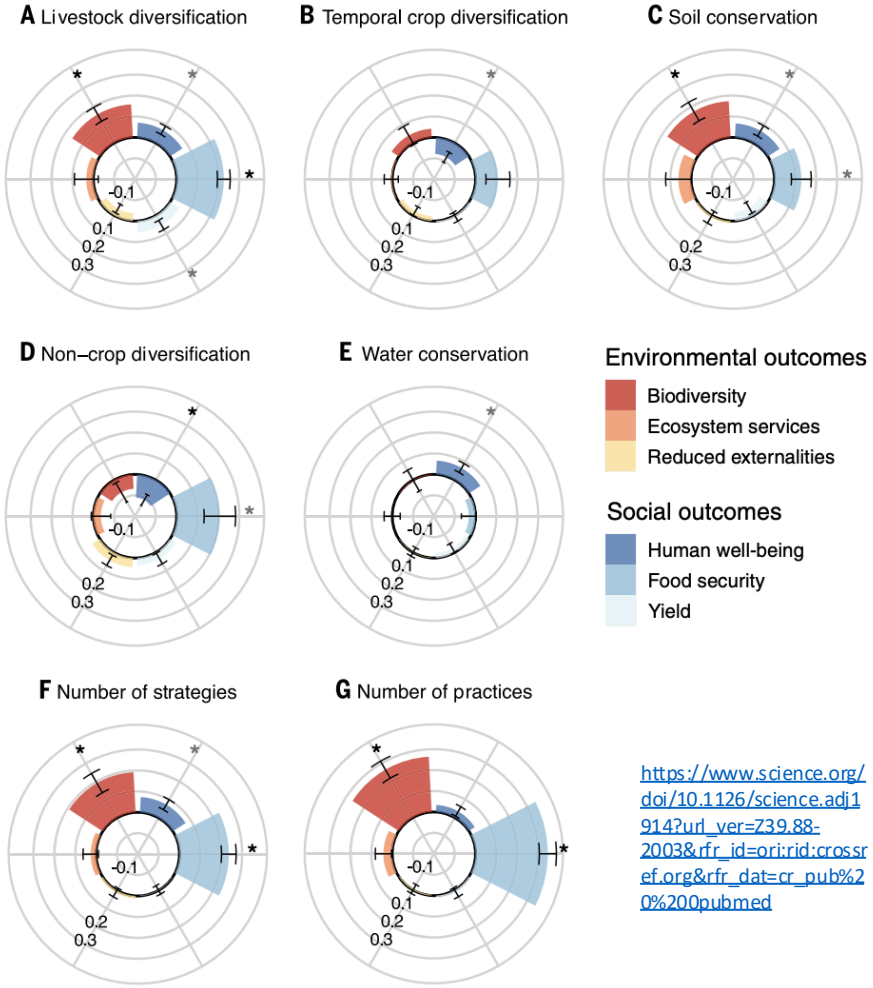
RESEARCH ARTICLE | FARMING PRACTICES

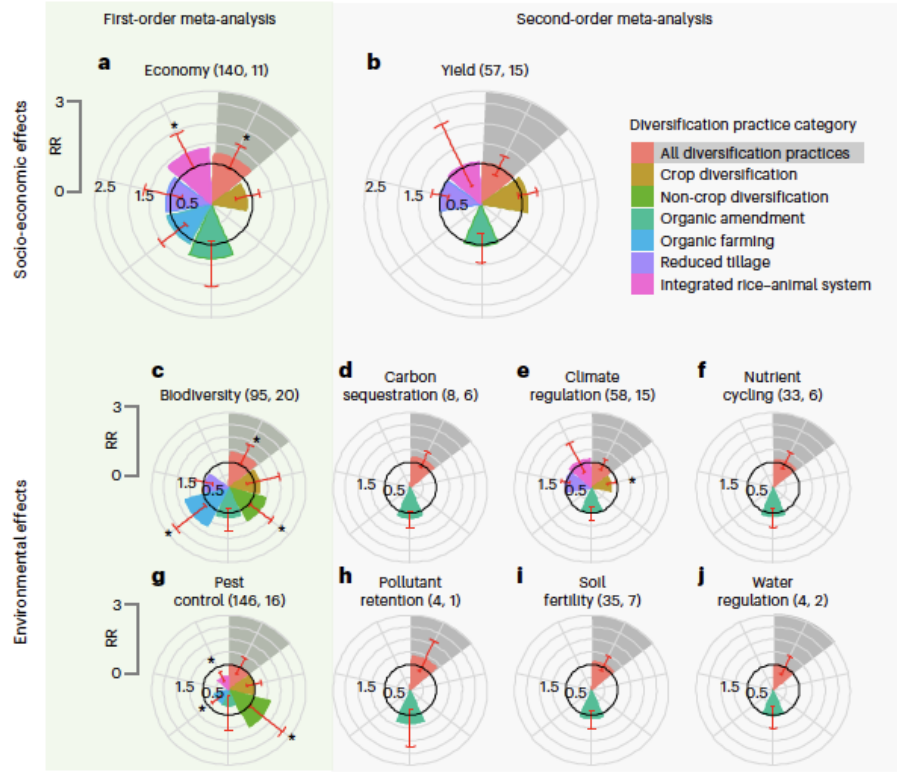
Joint environmental and social benefits from diversified agriculture

LAURA VANG RASMUSSEN, INGO GRASS, ZIA MEHRABI, OLIVIA M. SMITH, RACHEL BEZNER-KERR, JENNIFER BLESH, LUCAS ALEJANDRO GARIBALDI, MARNEY E. ISAAC, CHRISTINA M. KENNEDY, [...], AND CLAIRE KREMEN +49 authors Authors Info & Affiliations

SCIENCE · 4 Apr 2024 · Vol 384, Issue 6691 · pp. 87-93 · DOI: 10.1126/science.adj1914



https://www.science.org/doi/10.1126/science.adj1914?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed



Agricultural diversification can increase biodiversity by 40%, improve economy by 26% and reduce crop damage by 31%. Trade-off analysis showed that agricultural diversification in rice production promotes win–win scenarios between yield and other ecosystem services in 81% of cases

He, X., Batáry, P., Zou, Y. *et al.* Agricultural diversification promotes sustainable and resilient global rice production. *Nature Food* **4**, 788–796 (2023). https://doi.org/10.1038/s43016-023-00836-4

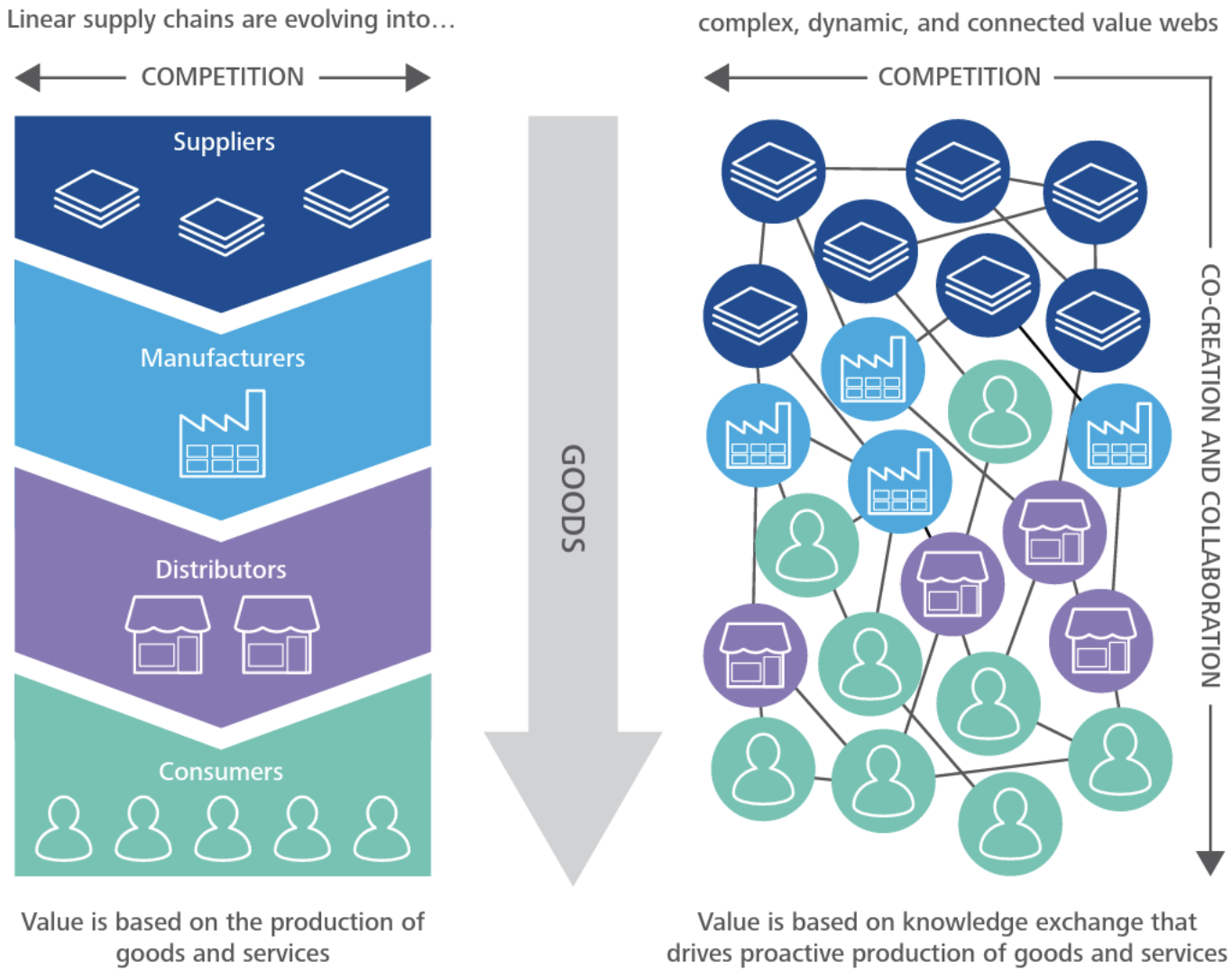
Ecosystems are dynamic and co-evolving communities of diverse actors who create new value through increasingly productive and sophisticated models of both collaboration and competition.

Read more about our view of business ecosystems in the Introduction.

Supply chains are increasingly becoming value webs that span and connect whole ecosystems of suppliers and collaborators; properly activated, they can play a critical role in reshaping business strategy and delivering superior results.

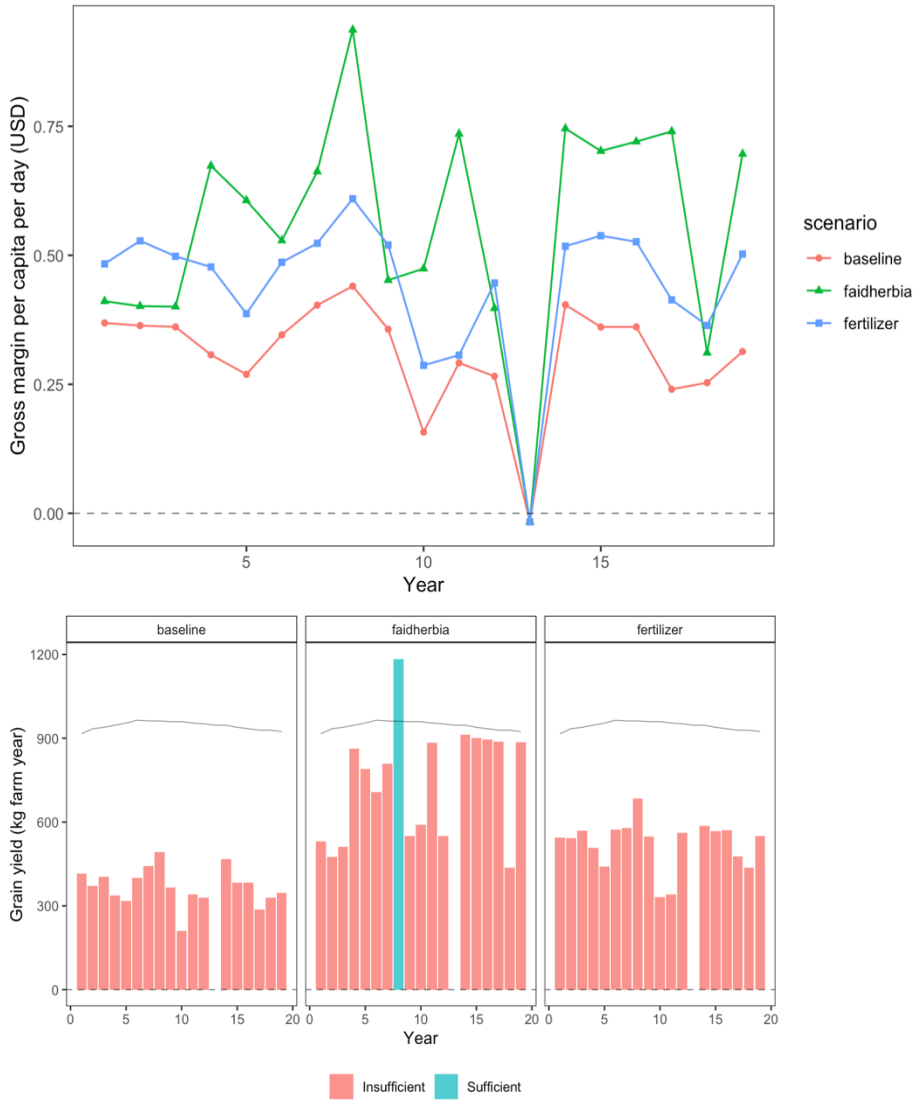
Kelly E and Marchese K (2015).
Supply chains and value webs.
Deloite University Press.

Value chains evolve into **value networks**



https://www2.deloitte.com/content/dam/Deloitte/za/Documents/strategy/za_Supply_chains_and_value_webs.pdf

Farmers' eye view of value webs - producing a diversity of products within a complex livelihood

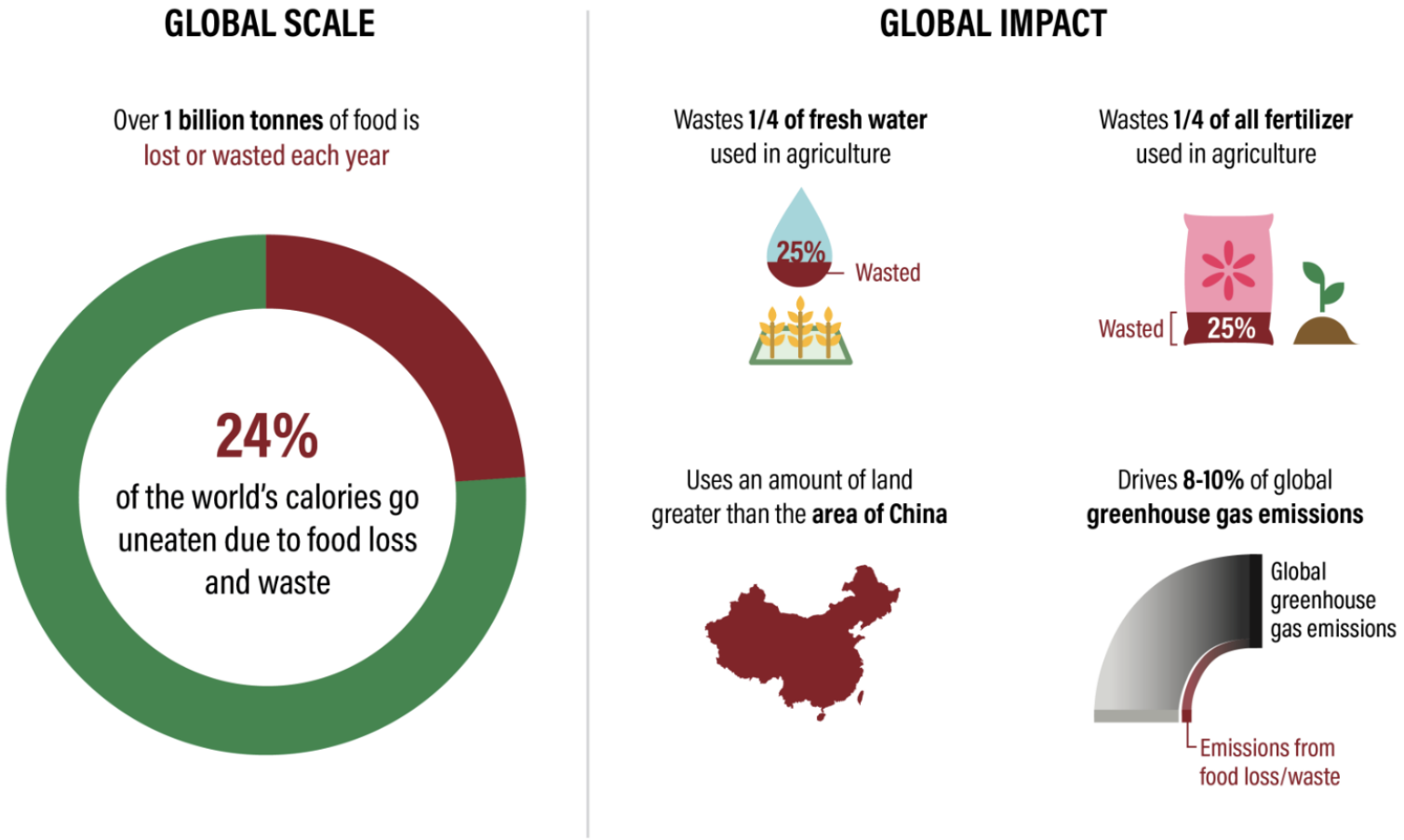


Livelihood trajectory modelling example – business case for incorporating fertiliser trees in fields in Ethiopia versus use of N fertiliser

Performance indicators (from the farmers' perspective)	BAU (no on-farm trees or fertiliser)	Agroforestry option 1 faidherbia in-field trees	Option 2 BAU with application of nitrogen fertiliser
Additional days of grain for the family compared to BAU (day yr^{-1})	NA	+136.9 (89.7)	+56.8 (23.7)
Additional days of fodder for livestock compared to BAU (day yr^{-1})	NA	+80.8 (64.6)	+54.9 (21.4)
Dung burnt as fuel (kg yr^{-1})	1,140.8 (181.8)	639.1 (554.6)	1,140.8 (181.8)
Dung applied to crop (kg yr^{-1})	3.0 (0.9)	477.5 (533.4)	3.0 (0.9)
Labour collecting wood from the forest (hour yr^{-1})	412.8 (57.0)	191.3 (220.4)	412.8 (57.0)
Labour managing on-farm trees (hour yr^{-1})	25.2 (38.1)	234.1 (354.0)	25.2 (38.1)
Total farm labour (hour yr^{-1})*	579.3 (579.3)	566.7 (278.8)	579.3 (579.3)
Returns to labour (USD $hour^{-1}$)	4.4 (1.3)	7.7 (2.7)	6.3 (1.8)
Gross margin returns from farm** (USD capita yr^{-1})	122.0 (45.7)	446.9 (398.3)	171.0 (55.6)
Gross margin returns from farm** (USD farm yr^{-1})	731.8 (274.4)	2,681.7 (2,389.7)	1,025.8 (333.4)

Source: Crossland et al (2023) in FAO Guide to developing business cases for agroforestry (forthcoming)

Globally, **30% of food is lost or wasted**. Around **13% of food produced is lost between harvest and retail**, while an estimated **17% is wasted** in households, in the food service and in retail all together (FAO).



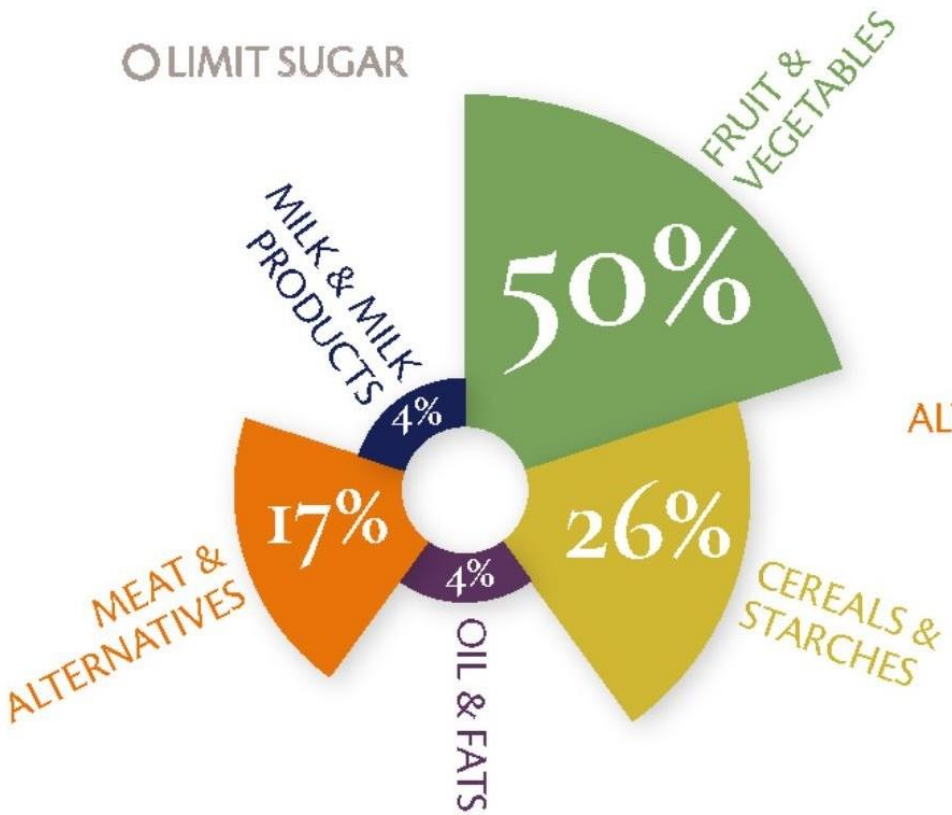
Reducing food loss and waste **before consumption** is vital alongside recycling waste **after consumption –** food regulations apply

Note: we can biologically fix N but need to return P and K to soil

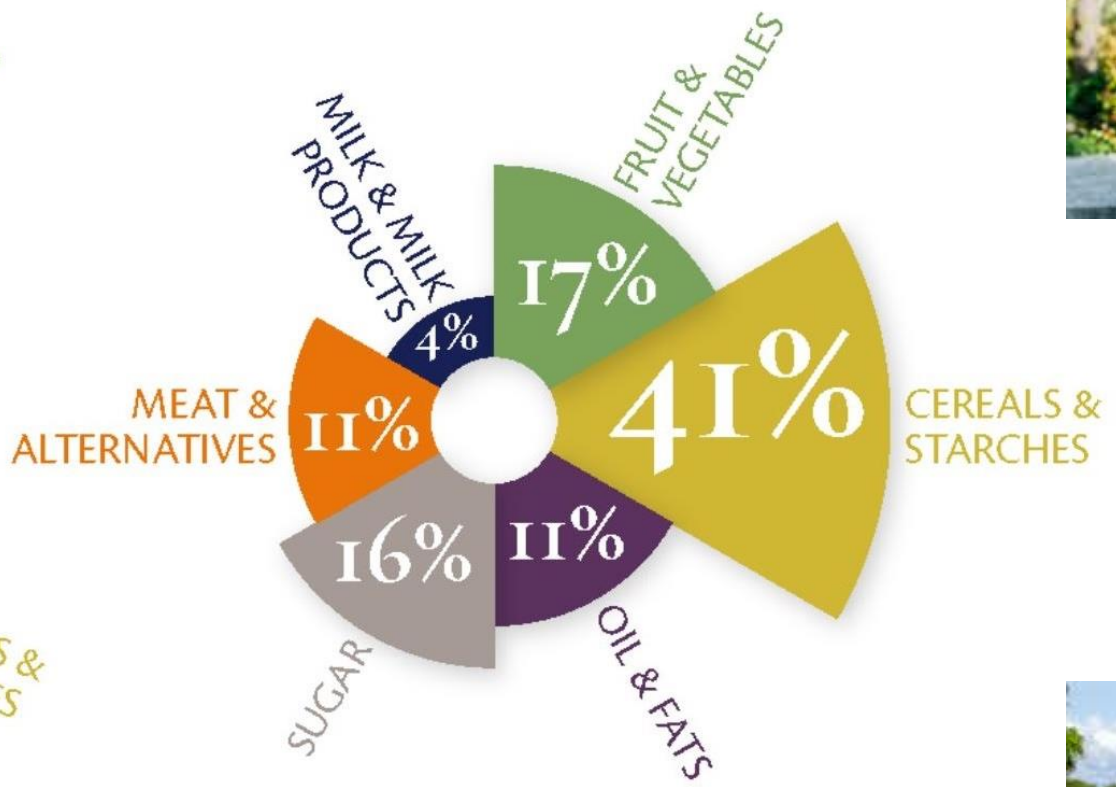
Changing attitudes to food and how it is produced, processed and consumed is the cutting edge

The mismatch between what food is produced globally, and what is required for healthy and balanced diets

How we should be eating
(Harvard's healthy eating plate model)



What we are actually producing
(According to 2011 FAO)

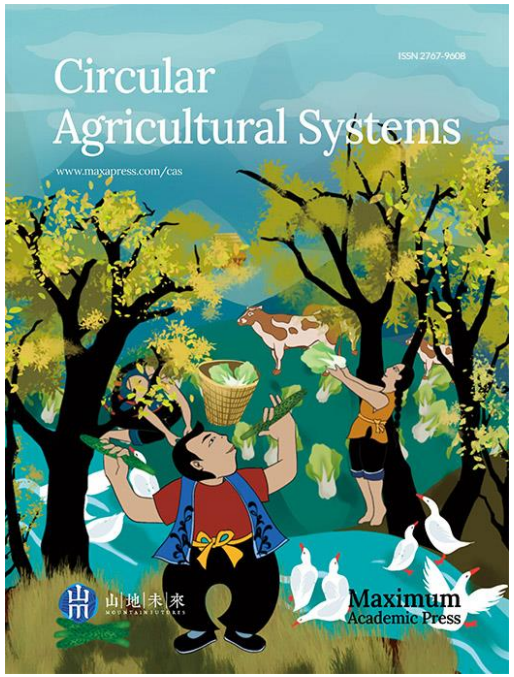


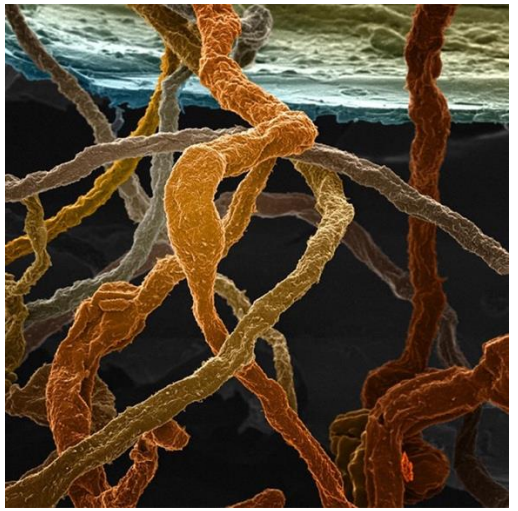
Source: Redrawn from data in KB KC et al. (2018)[158]

https://www.teseopress.com/theglobalfoodsystem/chapter/chapter-ii-food-consumption-patterns-necessary-changes/

Recycling and more circular economies

Black soldier fly larvae can efficiently convert organic waste, including food scraps and manure, into high-quality protein and fertilizer. The cultivation of BSF significantly reduces waste disposal impacts, **creates jobs**, enhances food security through animal feed production and organic fertilizer availability

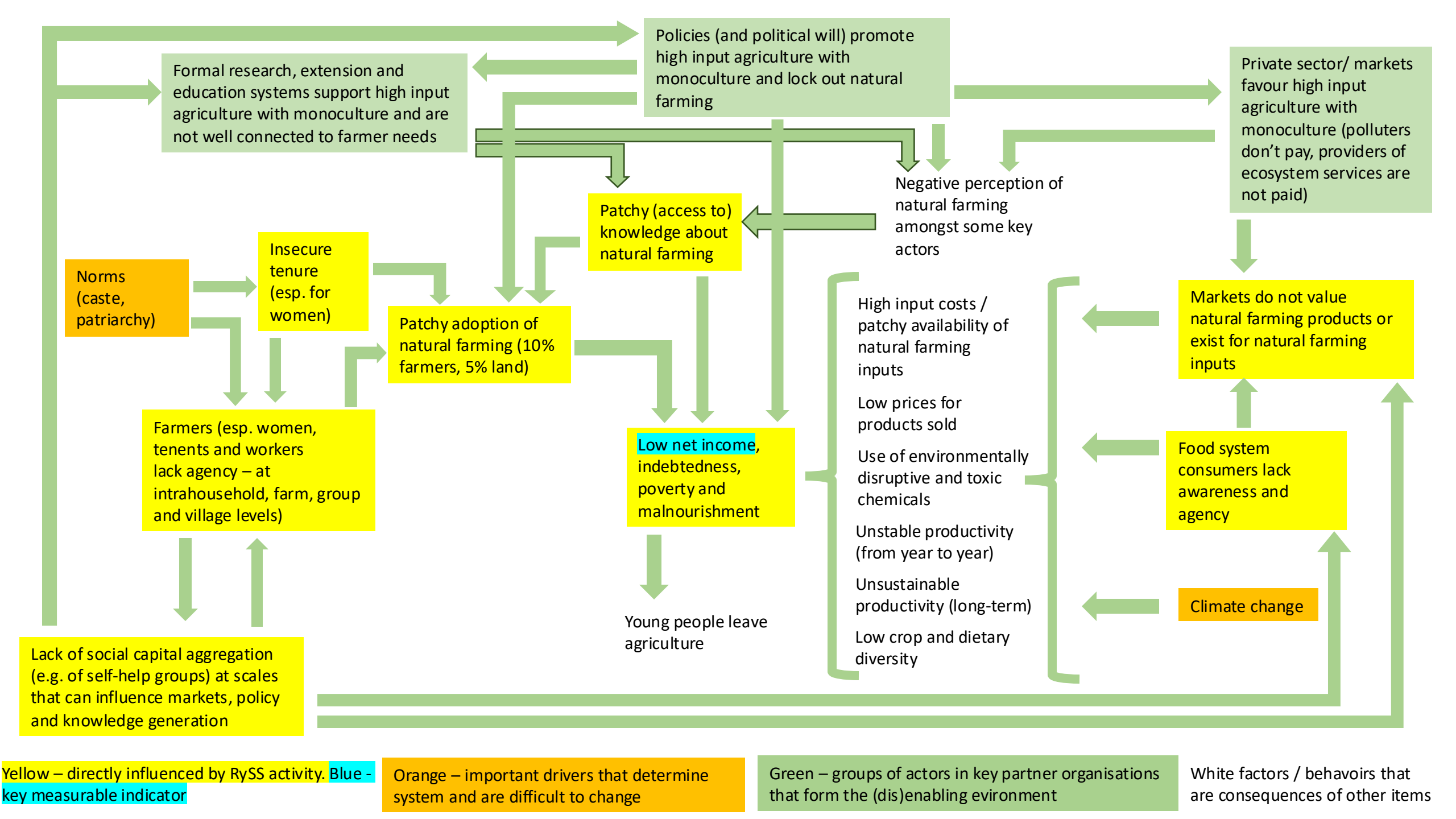


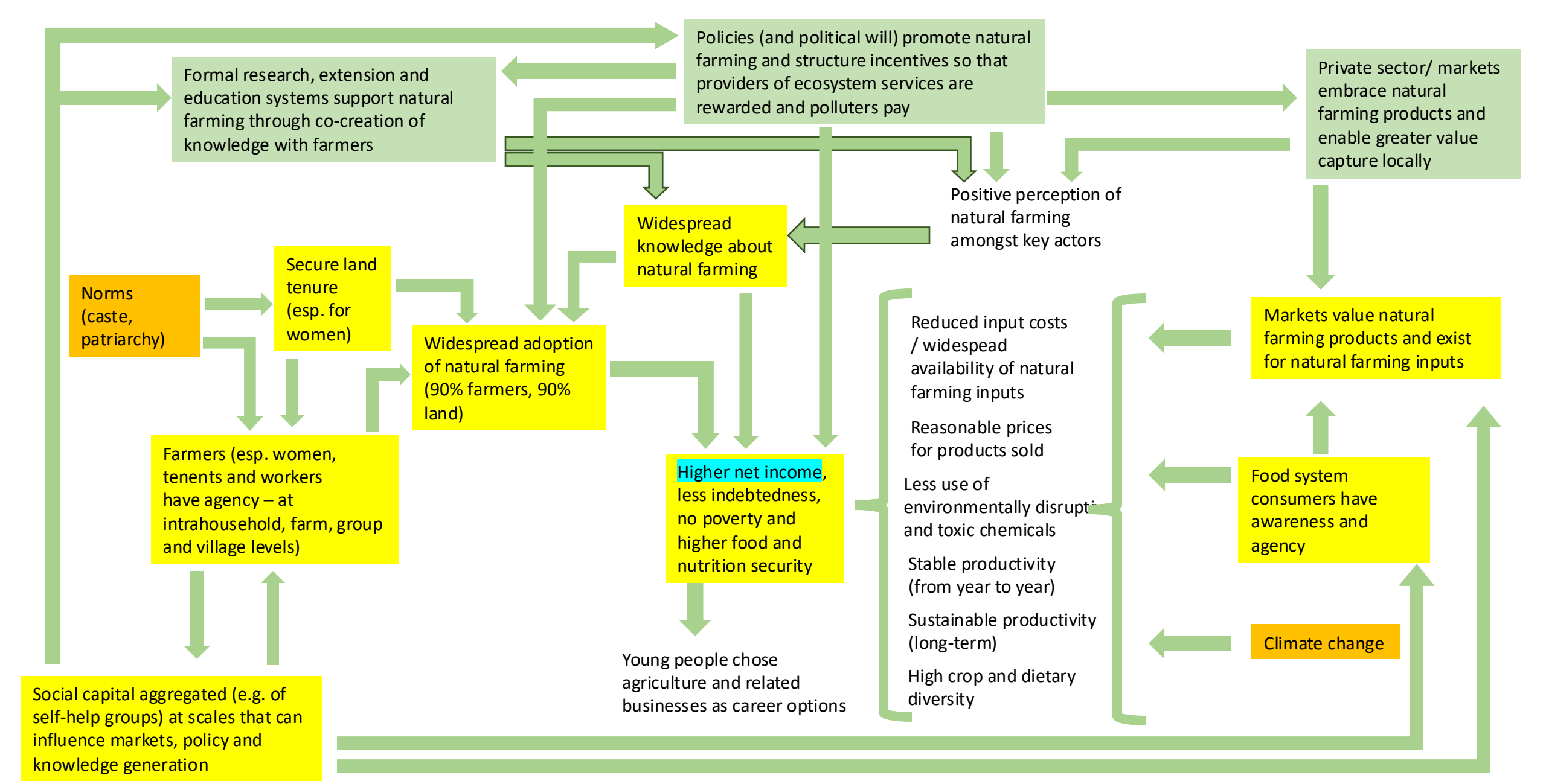


The fungus *Trichoderma reesei*, rapidly converts biomass to fuels. The fungus is known for its profuse production of biomass-degrading enzymes, which enhance the conversion process.

Filamentous fungi (mold) reduce solid waste (feaces) while converting it into a consumable, high protein food product.

Tepper, K., Edwards, O., Sunna, A. *et al.* Diverting organic waste from landfills via insect biomanufacturing using engineered black soldier flies (*Hermetia illucens*). *Commun Biol* **7**, 862 (2024). https://doi.org/10.1038/s42003-024-06516-8


Policies (and political will) promote high input agriculture with monoculture and lock out natural farming
Formal research, extension and education systems support high input agriculture with monoculture and are not well connected to farmer needs
Private sector/ markets favour high input agriculture with monoculture (polluters don't pay, providers of ecosystem services are not paid)
Negative perception of natural farming amongst some key actors
Patchy (access to) knowledge about natural farming
Norms (caste, patriarchy)
Insecure tenure (esp. for women)
Patchy adoption of natural farming (10% farmers, 5% land)
Farmers (esp. women, tenents and workers lack agency – at intrahousehold, farm, group and village levels)
Low net income, indebtedness, poverty and malnourishment
Young people leave agriculture
High input costs / patchy availability of natural farming inputs
Low prices for products sold
Use of environmentally disruptive and toxic chemicals
Unstable productivity (from year to year)
Unsustainable productivity (long-term)
Low crop and dietary diversity
Markets do not value natural farming products or exist for natural farming inputs
Food system consumers lack awareness and agency
Climate change
Lack of social capital aggregation (e.g. of self-help groups) at scales that can influence markets, policy and knowledge generation
Yellow – directly influenced by RySS activity. Blue - key measurable indicator
Orange – important drivers that determine system and are difficult to change
Green – groups of actors in key partner organisations that form the (dis)enabling evironment
White factors / behavoirs that are consequences of other items



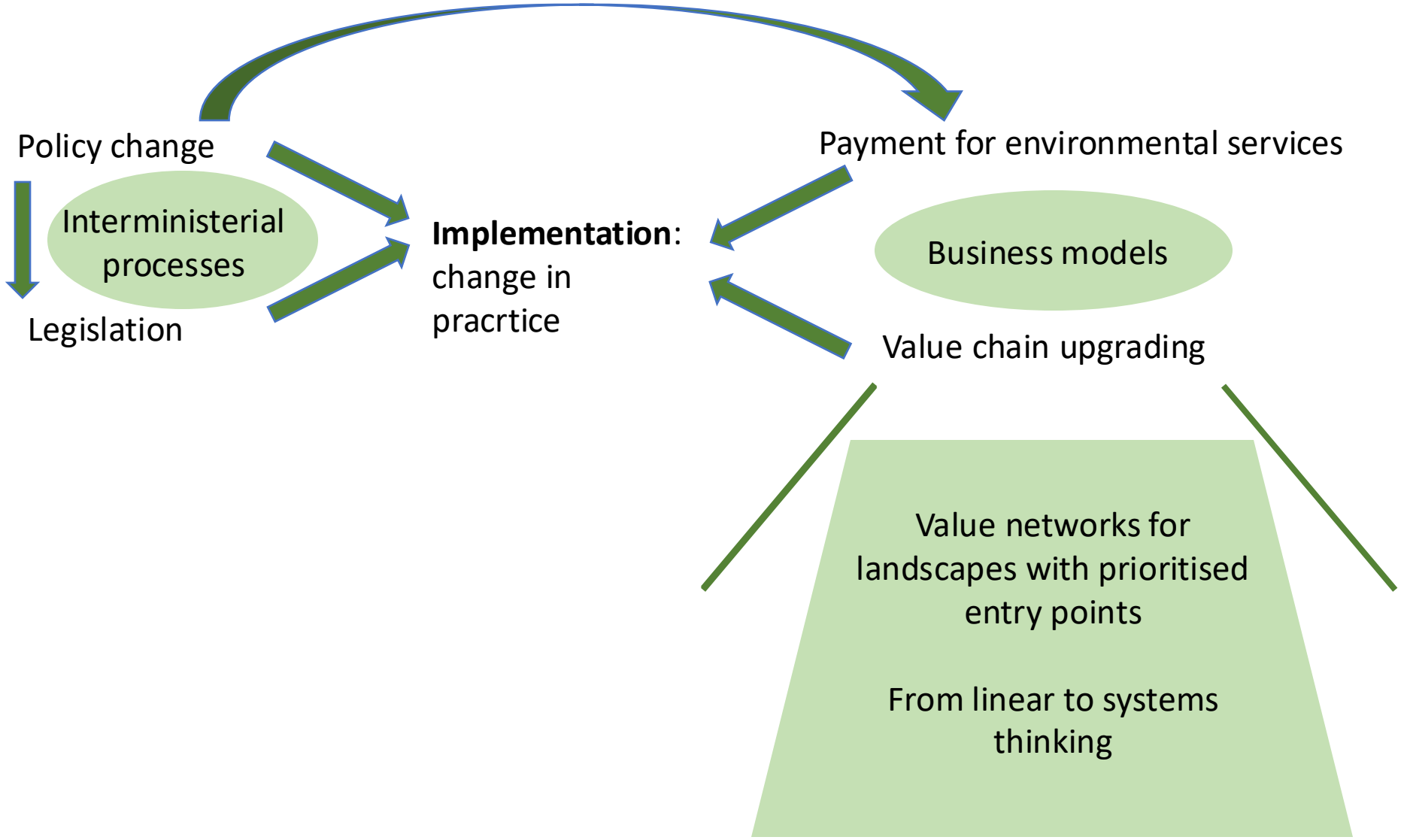
Yellow – significant change through directed effort during project – monitor for evaulation and learning.
Blue addressed by key deliverable

Orange – important drivers that are difficult to change but will be influenced

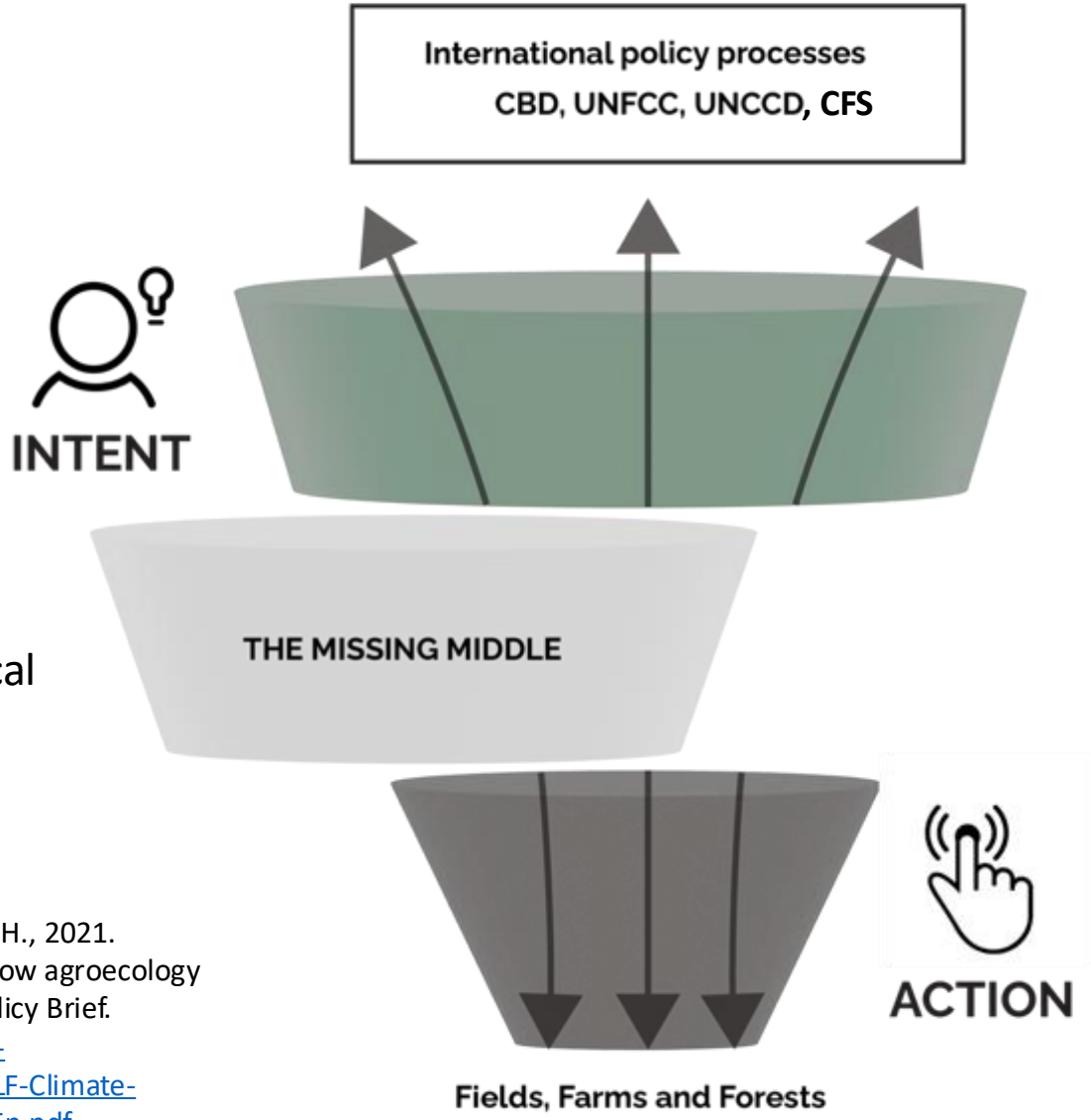
Green – pathways to change that cause change throughout system required as enabling evironment

White things that will change because of the focused yellow and green changes

Long term (sustainable) impact



A generic implementation challenge – the missing middle



National commitments

Sub-national implementation

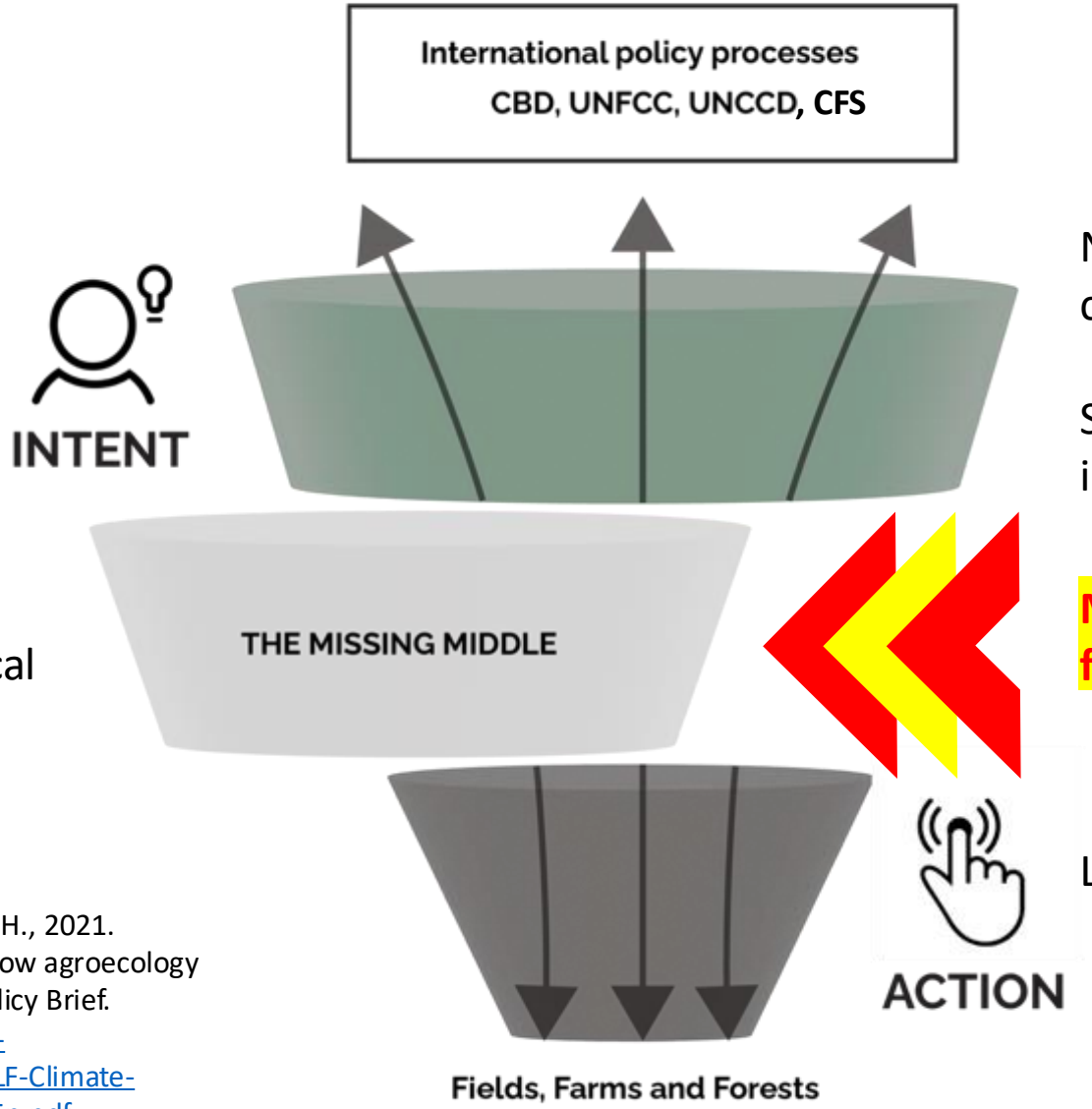
Cross–sectoral integration

Policy implementation at local landscape (territorial) scale

Local action

Weigelt, J, Sinclair F., Mikulcak, F and Lossak, H., 2021. Ecosystem-based adaptation in agriculture: how agroecology can contribute to tackling climate change. Policy Brief. https://www.globallandscapesforum.org/wp-content/uploads/2021/11/6-White-Paper_GLF-Climate-Ecosystem-based-adaptation-in-agriculture_En.pdf

DeSira projects are plugging the **missing middle**: a generic implementation challenge in food system transformation



National commitments

Sub-national implementation

Cross–sectoral integration

Policy implementation at local landscape (territorial) scale

Multistakeholder platforms facilitated through DeSira projects

Local action

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Transformative Partnership Platform on agroecological approaches to building resilience of livelihoods and landscapes

https://glfx.globallandscapesforum.org/topics/21467/page/TPP-home

To join the Community of Practice, simply follow the steps below:

1. Create an account with GLFx
2. Confirm your email address in the registration process
3. Once inside the GLFx platform, navigate to 'Groups' and choose 'The Transformative Partnership Platform on Agroecology'
4. Select 'Join' and complete the sign-up form – now you're set and can browse resources, start a discussion, and much more!