Bringing Systems Science into Assessments of Sustainable Agricultural Intensification

Fergus Sinclair*, Constance Neely, Leigh Winowiecki, Tor-Gunnar Vågen, Ric Coe
World Agroforestry Centre (ICRAF)
FNSSA Workshop, European Commission, Brussels, 23 January 2017
*f.sinclair@cgiar.org

Sustainable Agricultural Intensification (SAI) – Key Researchable Issues

- Ecosystem service trade-offs and synergies
- The transformative power of trees and livestock
- Systems research at the scale of impact

Ecosystem service trade-offs and synergies

- Impacts of land use change on multiple ecosystem services
  - the food, energy, water nexus (provisioning)
  - water, soil, organism, gene flows (regulating)
  - soil carbon and soil health (supporting)
  - inertia associated with *cultural* practices in the face of climate change (maize, olives)
- Scale and resolution of tools to assess and map:
  - ecosystem structure, function (status) and service flows (source to receptor)
  - land degradation / restoration (standards, tipping points, distance from them)
- From decision to negotiation support
  - bringing data and participatory processes together
  - dealing with multiple and competing knowledge systems – local, scientific, policy
  - recongnising ecosystem service outcomes are emergent properties of complex systems

Food-Water-Energy Nexus

Food

Water

Energy

The cropping 'system' concept

Package of measures to increase crop productivity by using inputs to make the environment as suitable as possible for the crop – need to watch sustainability esp. with respect to soil carbon and micronutrients

Fertiliser

Crop varieties

Agro-chemicals

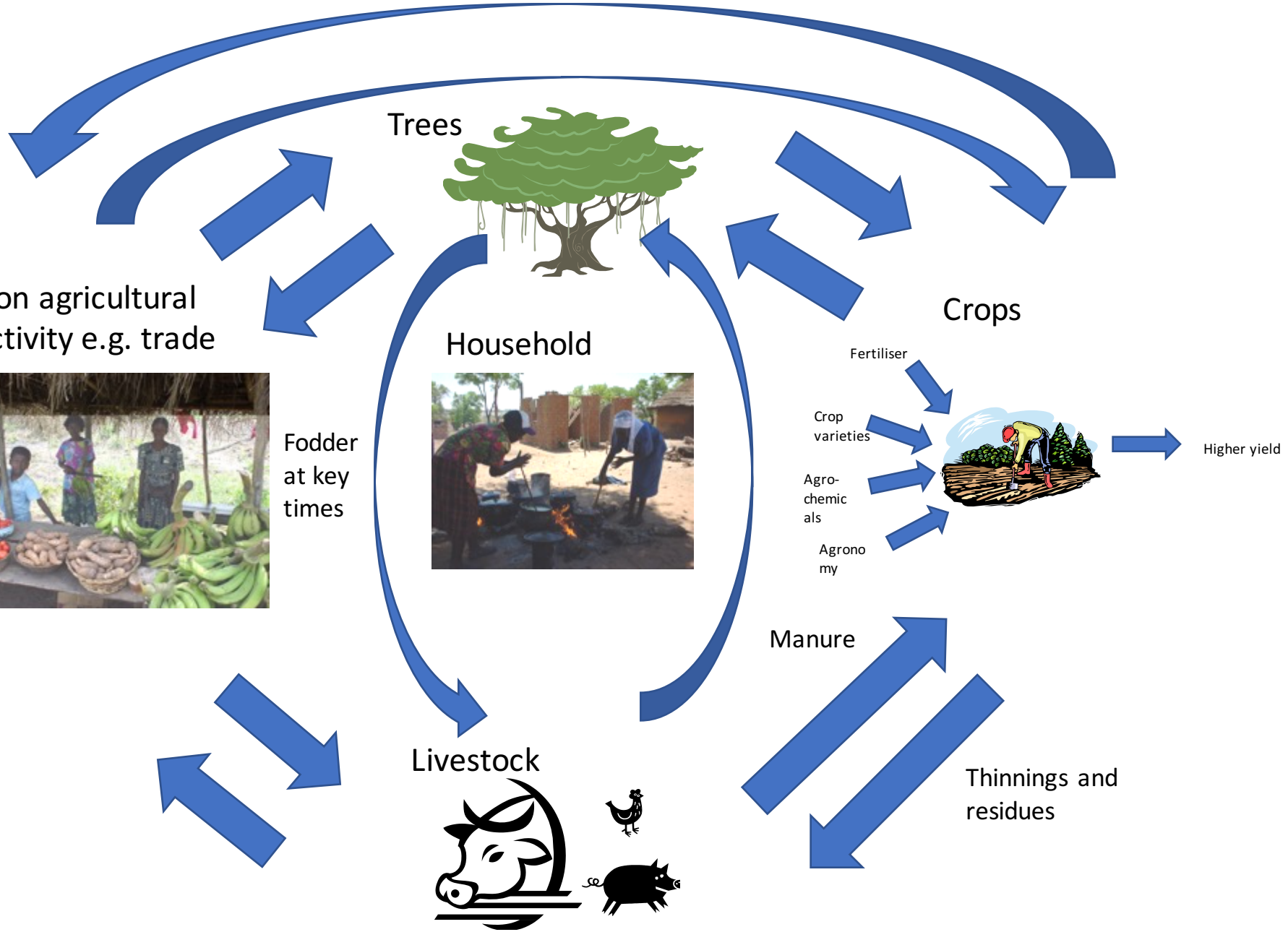
Agronomy

Higher yield

Assumes that the crop is fairly independent of the rest of the livelihood system – which (with due regard to sustainability) is appropriate for a subset of wealthier farmers in Africa

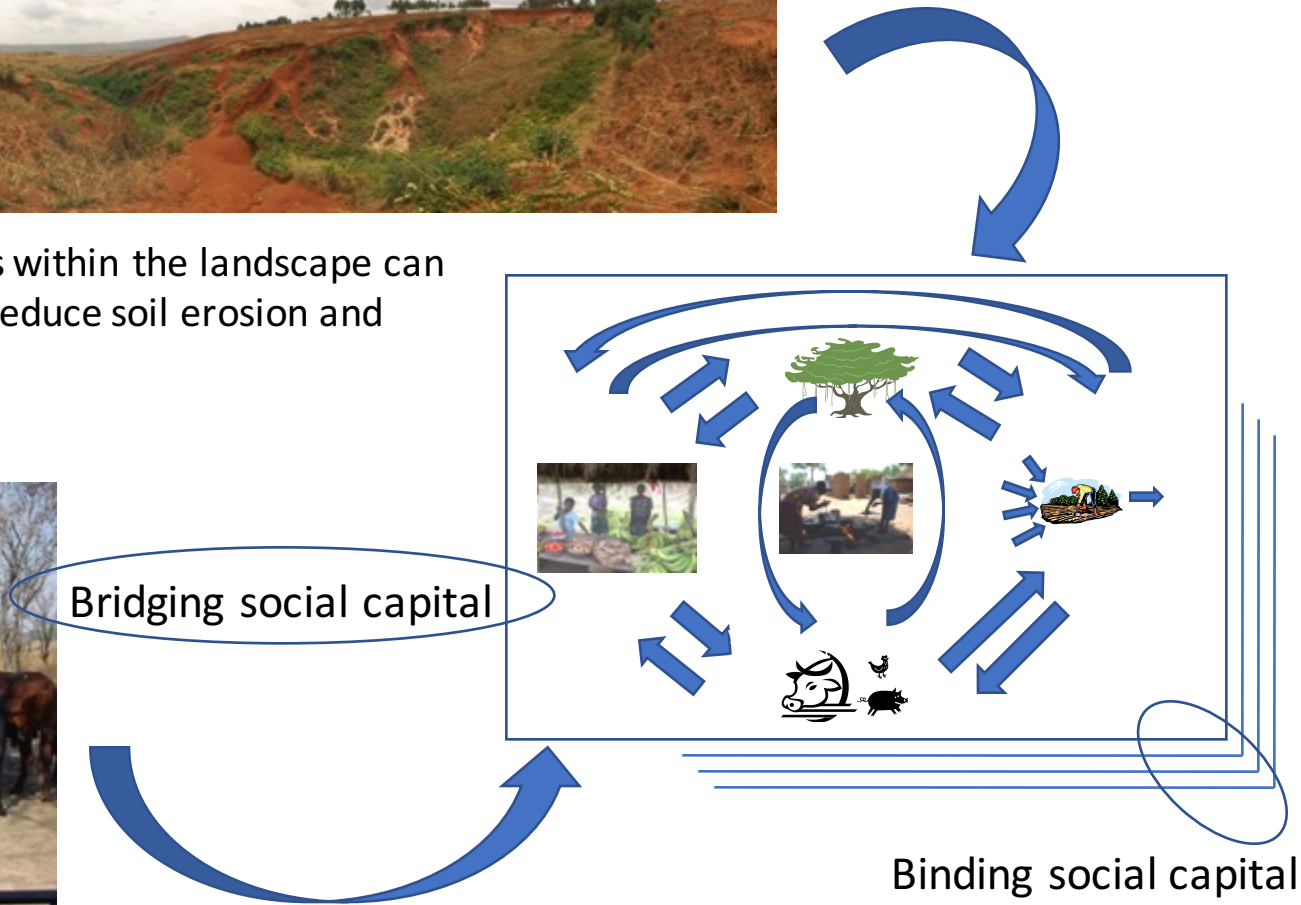
Sinclair F.L. (2017). Systems science at the scale of impact: reconciling bottom-up participation with the production of widely applicable research outputs. *In* Oborn I, Vanlauwe, B., Phillips M, Thomas R, Brooijmans, W. and Atta-Krah K. *Sustainable Intensification in Smallholder Agriculture: An Integrated Systems Research Approach*. London: Earthscan.

Crops within a livelihood system reality



Livelihood systems within a landscape context

Strategic placement of trees within the landscape can increase water infiltration, reduce soil erosion and improve water productivity



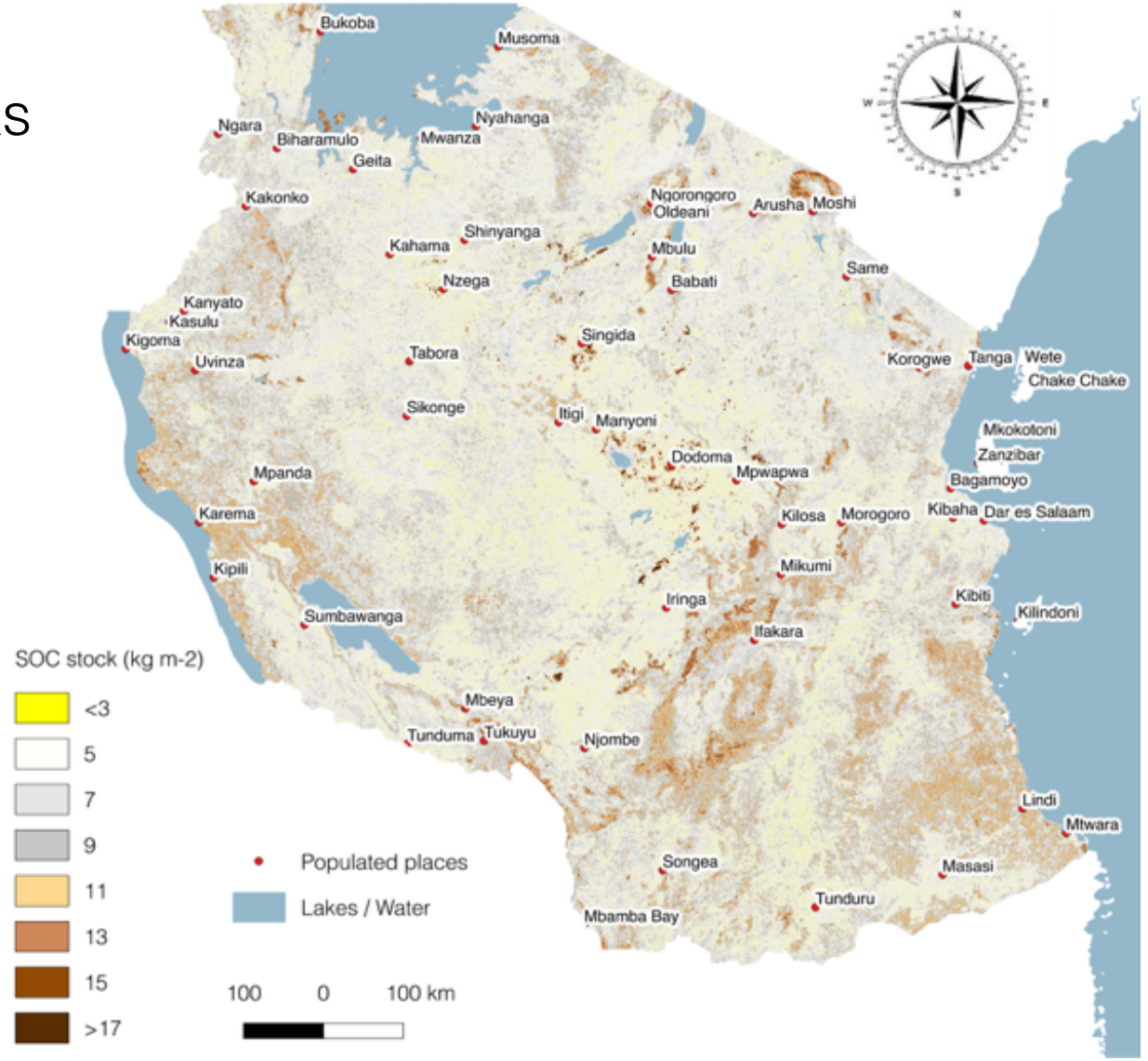
Livestock move nutrients within and between landscapes often from common forest and grazing areas to crop land; livestock may be owned by farm households within the landscape or by separate pastoralist communities

Ecosystem service trade-offs and synergies

- Impacts of land use change on multiple ecosystem services
  - the food, energy, water nexus (provisioning)
  - water, soil, organism (gene) movement (regulating)
  - soil carbon and soil health (supporting)
  - inertia associated with cultural practices in the face of climate change (maize, olives)
- Scale and resolution of tools to assess and map:
  - ecosystem structure, function (status) and service flows (source to receptor)
  - land degradation / restoration (standards, tipping points, distance from them)
- From decision to negotiation support
  - bringing data and participatory processes together
  - dealing with multiple and competing knowledge systems – local, scientific, policy
  - recongnising ecosystem service outcomes are emergent properties of complex systems

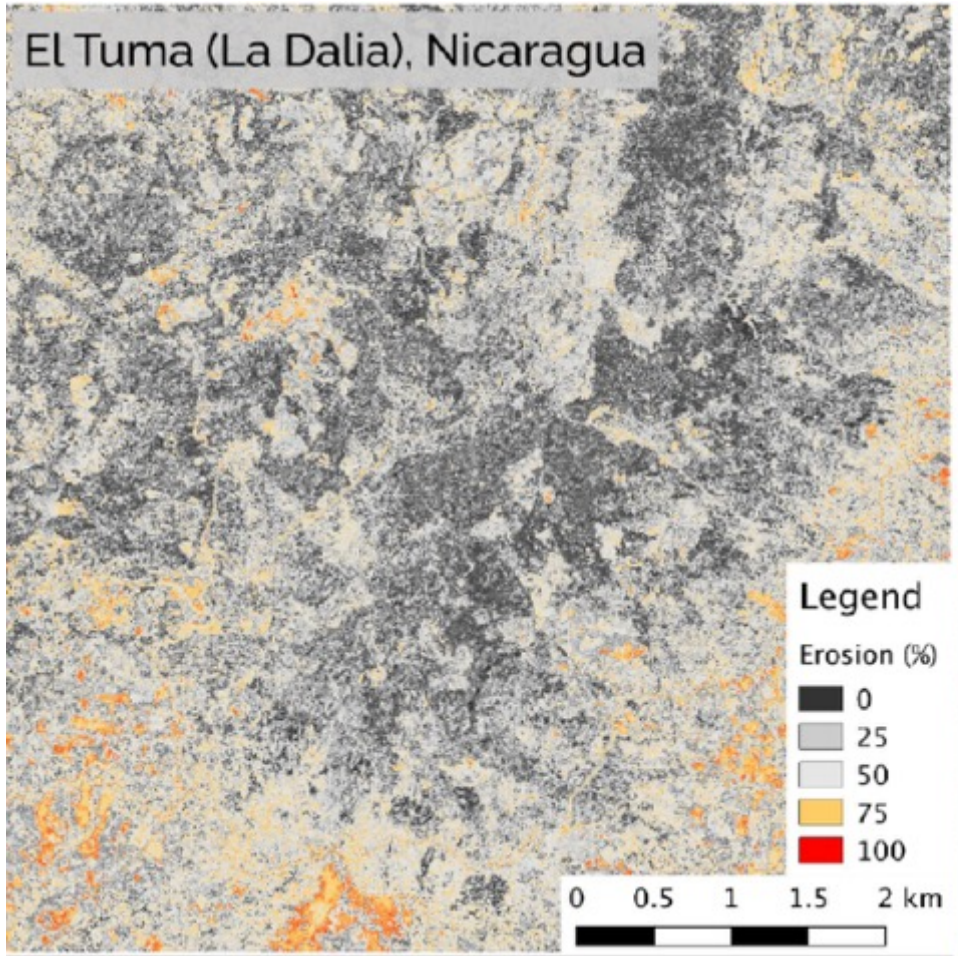
Spatial Assessment of Carbon Accounting

New method for assessing SOC stocks

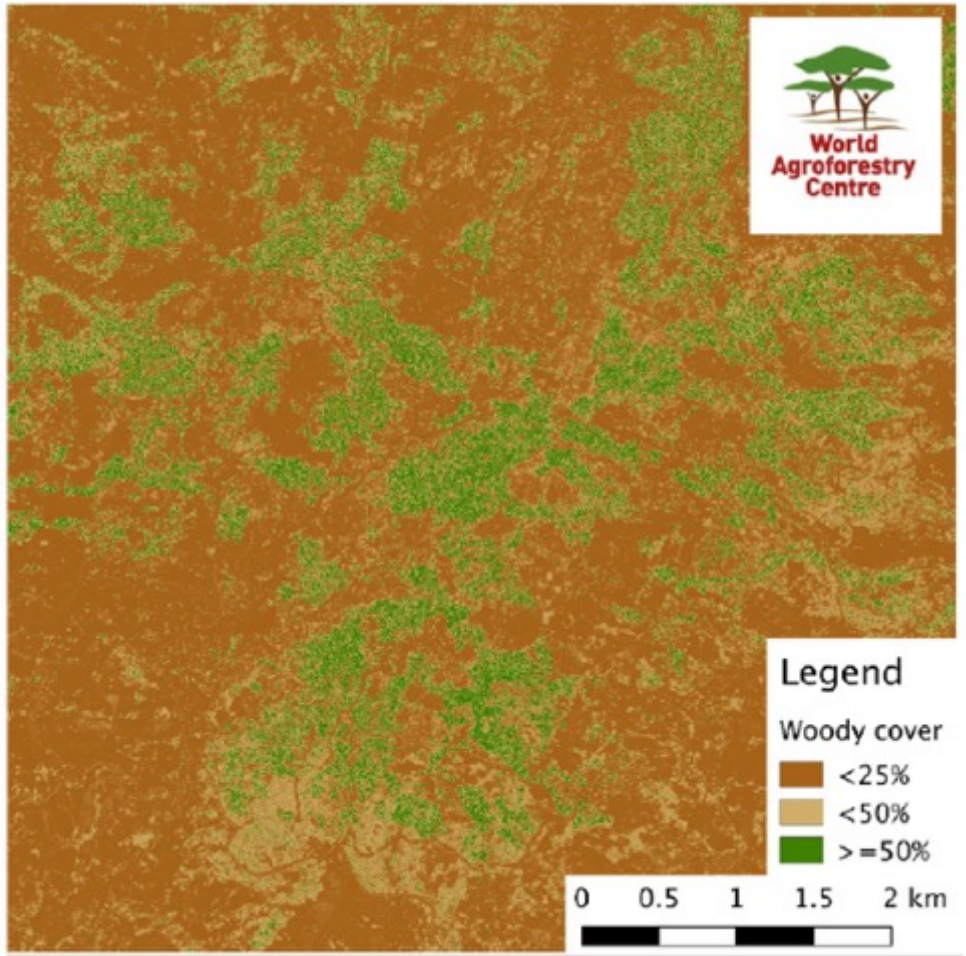


Winowiecki et al., 2016, SOC stocks to 30 cm, 500 m resolution

http://www.sciencedirect.com/science/article/pii/S0016706115000816



LAND DEGRADATION RISK
Soil erosion prevalence @5m resolution



VEGETATION STRUCTURE
Woody cover @5m resolution

Spatial Assessments of Land Degradation and Vegetation Structure

Tor-Gunnar Vågen
World Agroforestry Centre
[t.vagen@cgiar.org]

Reconciling global comparative versus locally relevant indicators?

System boundaries understanding ES flows from generation to reception

Using resolutions and scales that can inform field and farm level decisions

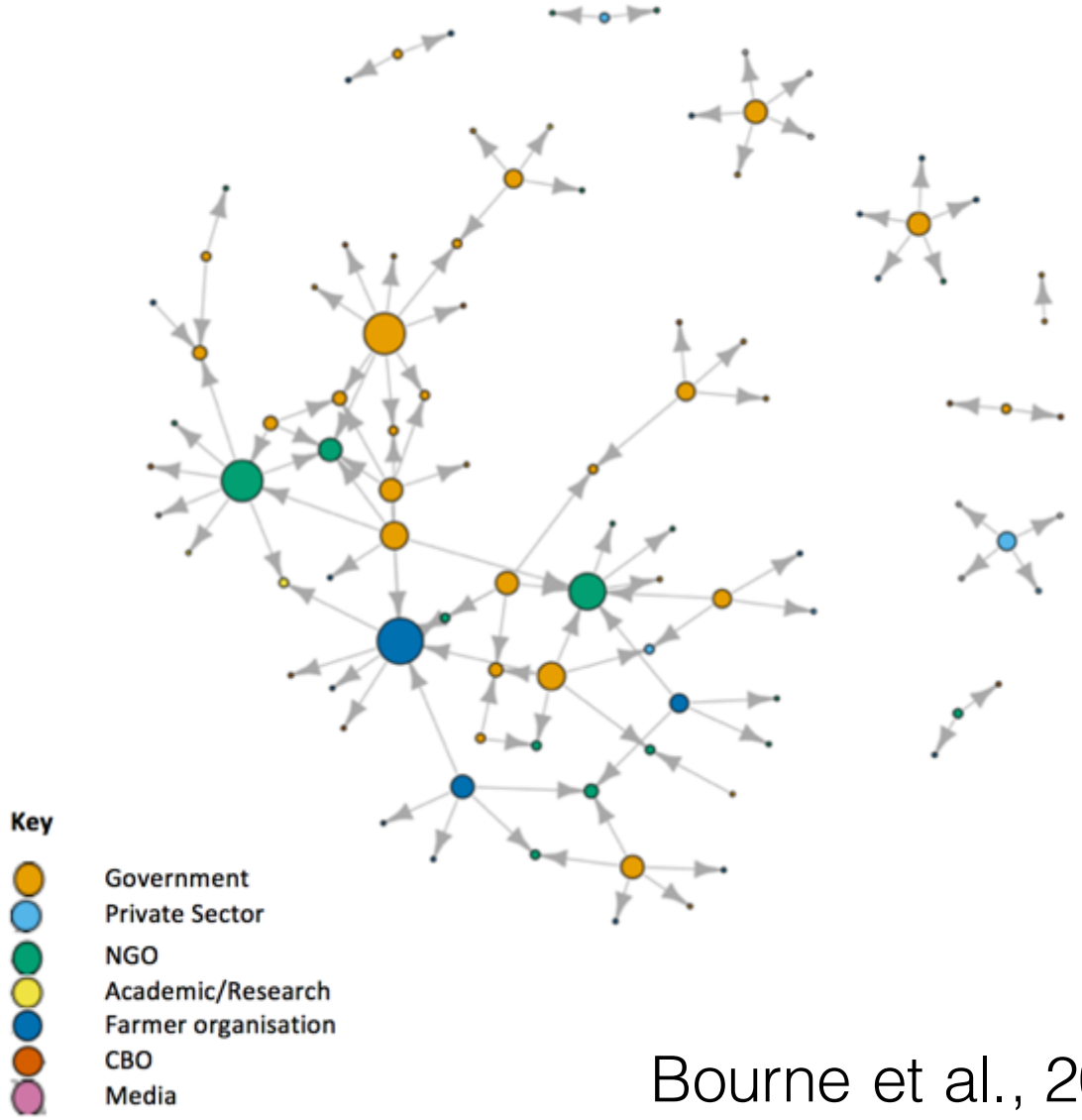
Defining tipping points for degradation and distances from them

Social Network Analysis

Mbarali District, Tanzania

- Who are the actors in SAI?
- How is SAI information disseminated?

Connectivity amongst many actors but some parts of the network are disconnected, limiting information and knowledge flow. Opportunities to enhance connectivity are apparent. Government, NGO's and Farmer organisations appear to link a number of actors in the network. MVIWITA,RIEFP, RUDI were the most connected stakeholders in the network.

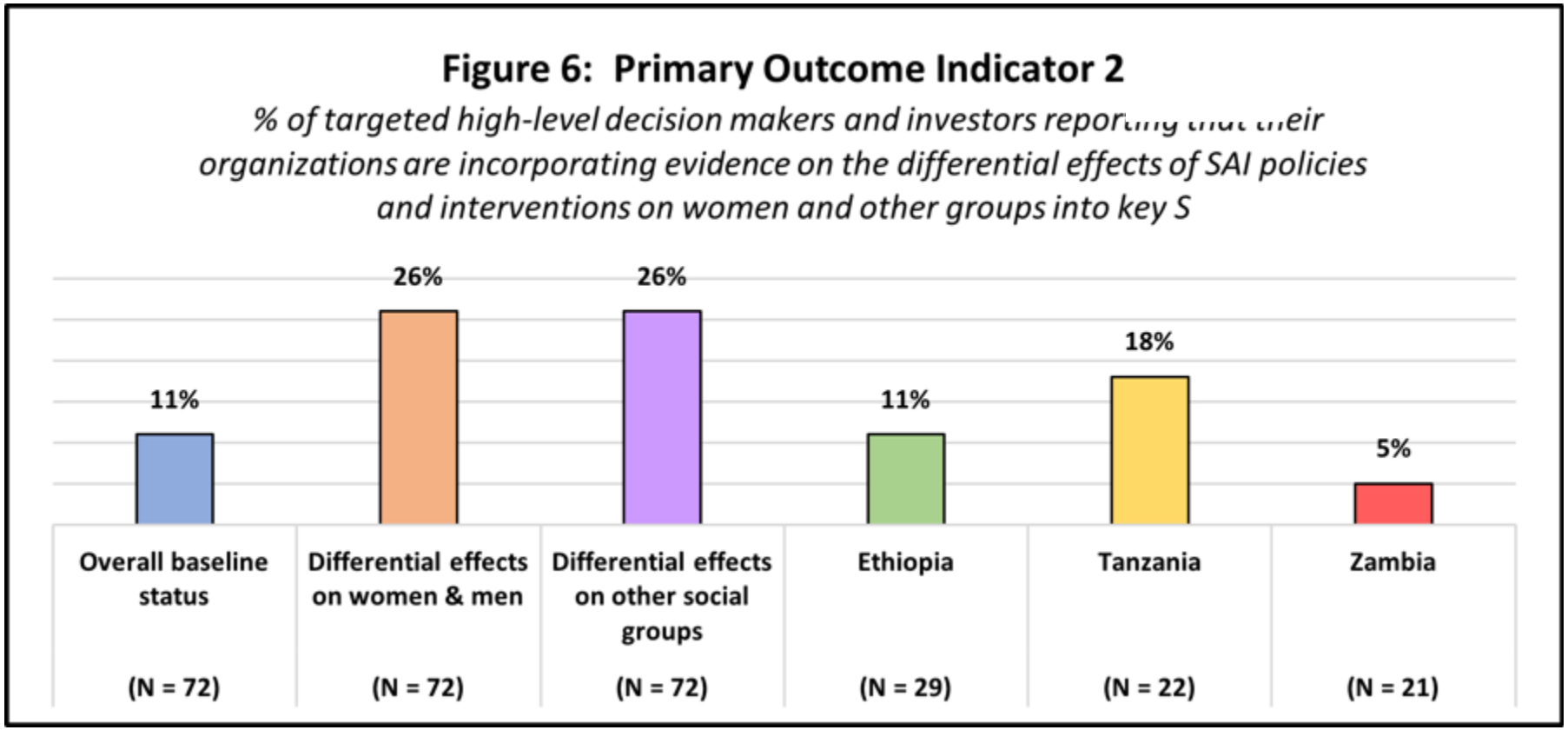


Bourne et al., 2016

http://www.worldagroforestry.org/project/bringing-evidence-bear-negotiating-ecosystem-service-and-livelihood-trade-offs-sustainable

Assessing Stakeholders Engagement with Evidence:

The overall baseline indicates that only 11% of decision makers are incorporating evidence on differential effects of SAI Practices in Zambia, Ethiopia and Tanzania.



http://www.worldagroforestry.org/project/bringing-evidence-bear-negotiating-ecosystem-service-and-livelihood-trade-offs-sustainable

Hughes, Bourne et al 2016

Ecosystem service trade-offs and synergies

- Impacts of land use change on multiple ecosystem services
  - the food, energy, water nexus (provisioning)
  - water, soil, organism (gene) movement (regulating)
  - soil carbon and soil health (supporting)
  - inertia associated with cultural practices in the face of climate change (maize, olives)
- Scale and resolution of tools to assess and map:
  - ecosystem structure, function (status) and service flows (source to receptor)
  - land degradation / restoration (standards, tipping points, distance from them)
- From decision to negotiation support
  - bringing data and participatory processes together
  - dealing with multiple and competing knowledge systems – local, scientific, policy
  - recongnising ecosystem service outcomes are emergent properties of complex systems

http://landscapeportal.org/turkanaSHARED/

Neely, Chesterman, and Vågen and 2016

PLANNING

Understand context, establish desired outcomes and engagement plan

Facilitate stakeholder discussions to understand decision-making context

Clarify actors and 'owners' of decisions and rationalize desired outcomes

Collectively identify context relevant indicators of development success

Intended outputs:
- Desired development vision and outcomes
- Stakeholder engagement strategy
- Anticipated success indicators

ORGANIZING

Gather, integrate and analyze evidence

Gather evidence and identify applicable analysis tools

Utilize appropriate tools to generate trends, causal relationships, scenarios, risks and tradeoffs

Facilitate integration of evidence and knowledge domains

Intended outputs:
- Generate evidence from data and experience
- Tailored tools for decision application
- Integration among knowledge sources

Embedded learning and capacity for the decision making cycle

Continuous evaluation and review

SHARED
the decision-making hub

IMPLEMENTATION PRIORITIES

Interactive, collaborative learning and testing of decision options

Integrate evidence and knowledge inputs

Query knowledge sources and interpret evidence

Facilitate multi-way structured interaction to test options

Intended output:
- Interactive learning to allow for selection of decisions options towards desired outcome

MONITORING AND LEARNING

Action plan, implementation strategy and accompanying support structure

Create action plan and finalize implementation strategy – supporting information, resources and tools

Agree on response plan for monitoring success indicators

Intended outputs:
- Implementation strategy to achieve decision outcomes
- Monitoring plan based on success indicators and strategy for rapid response

The transformative power of trees and livestock

- System intensification to tackle climate change adaptation AND mitigation through managing interactions
- Nutrient and water flows at field, farm and landscape scales
  - tree cover influences infiltration and atmospheric water flows
  - manure is often more important than milk and meat
- Understanding soil biota
  - estimated that >30% of soils in Africa now non responsive, fragmented and fine-grained distribution
  - advances in genomics
  - move from trees associated with higher abundence and activity of beneficial organsims to density and diversity required to achieve specific soil health outcomes

Integrated Farming Systems, Tanzania

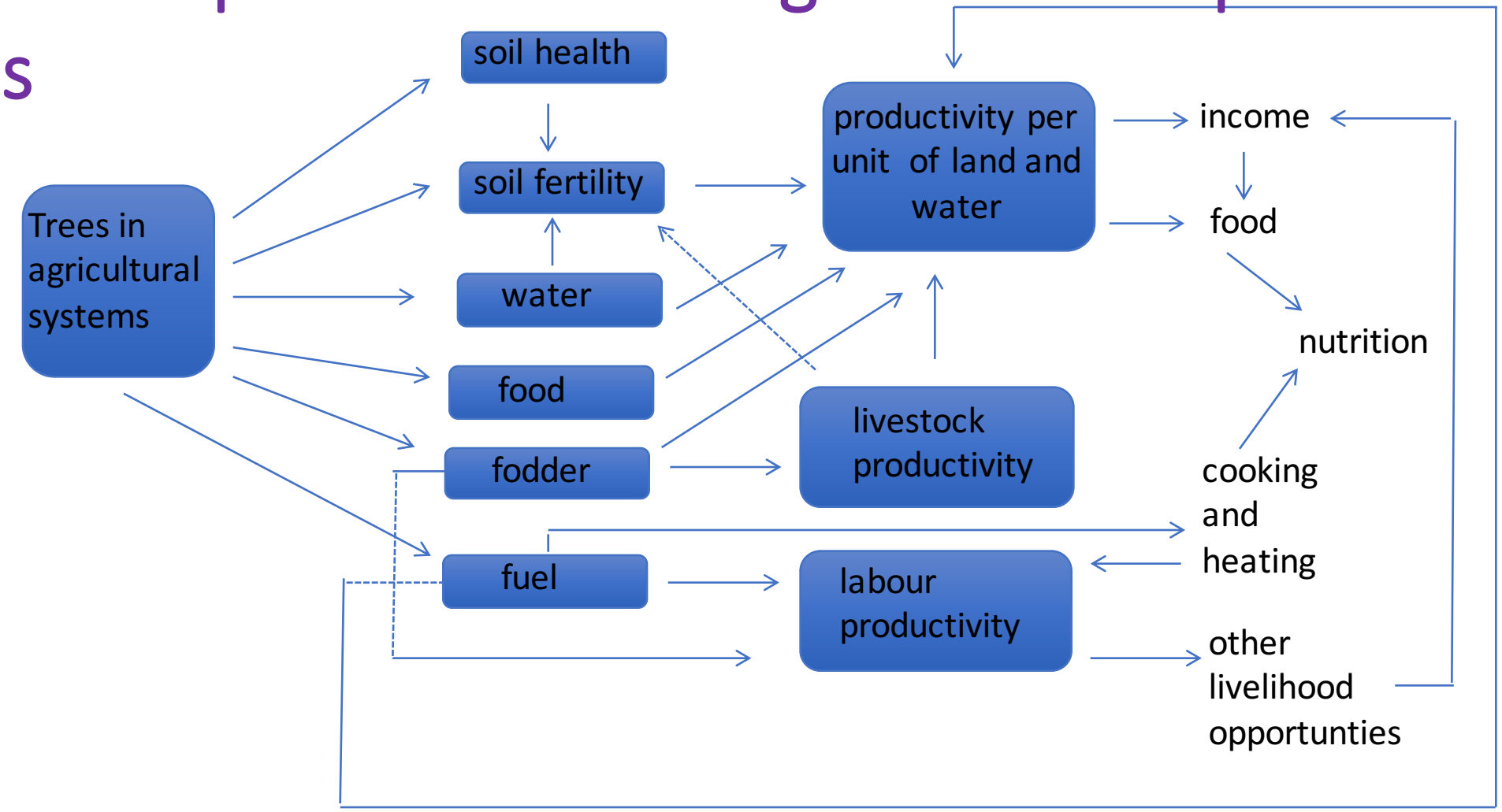
Photo Credits: Neely

Drylands Pastoral integrated System

Photo Credits: C.Neely

Field and landscape scale modeling of tree–crop interactions

Tools include:
APSIM
Simile
Polyscape
SHARED



Luedeling et al., 2016 Agricultural Systems. DOI: 10.1016/j.agsy.2015.11.005
Jackson et al., 2013 Polyscape. A GIS mapping framework providing efficient and spatially explicit landscape-scale valuation of multiple ecosystem service. Landscape and Urban Planning
Pagella and Sinclair, 2014 Development and use of a typology of mapping tools to assess their fitness for supporting management of ecosystem service provision. Landscape Ecology

Livestock Regenerating Landscapes

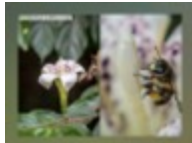
Photo Credits: A. Savory

Systems research at the scale of impact

- Testing and adapting options across fine-scale variation in context
- Expanding options (technology, extension system / market interventions, policy and institutions)
- Quantifying *diversity – resilience* linkages a variety of (orphan) crops and trees (many native) to suit different field, farm and landscape niches

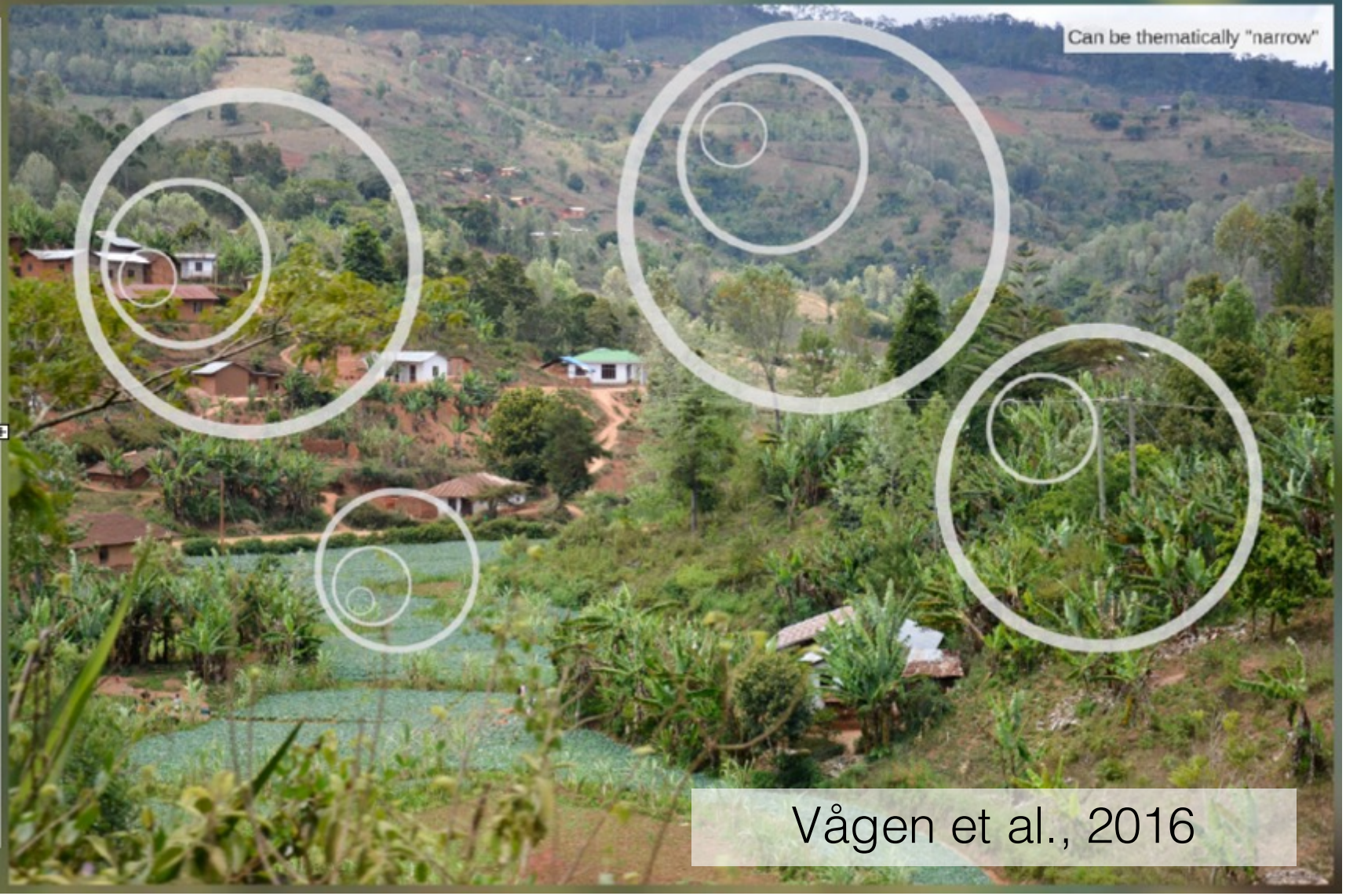
Coe, Sinclair, and Barrios. 2014 Scaling up agroforestry research 'in' rather 'for' development. Current Opinion in Environmental Sustainability

Smith-Dumont E, Bonhomme S, Pagella T and Sinclair F. 2017 Structured stakeholder engagement leads to development of more diverse and inclusive agroforestry options. *Experimental Agriculture*.



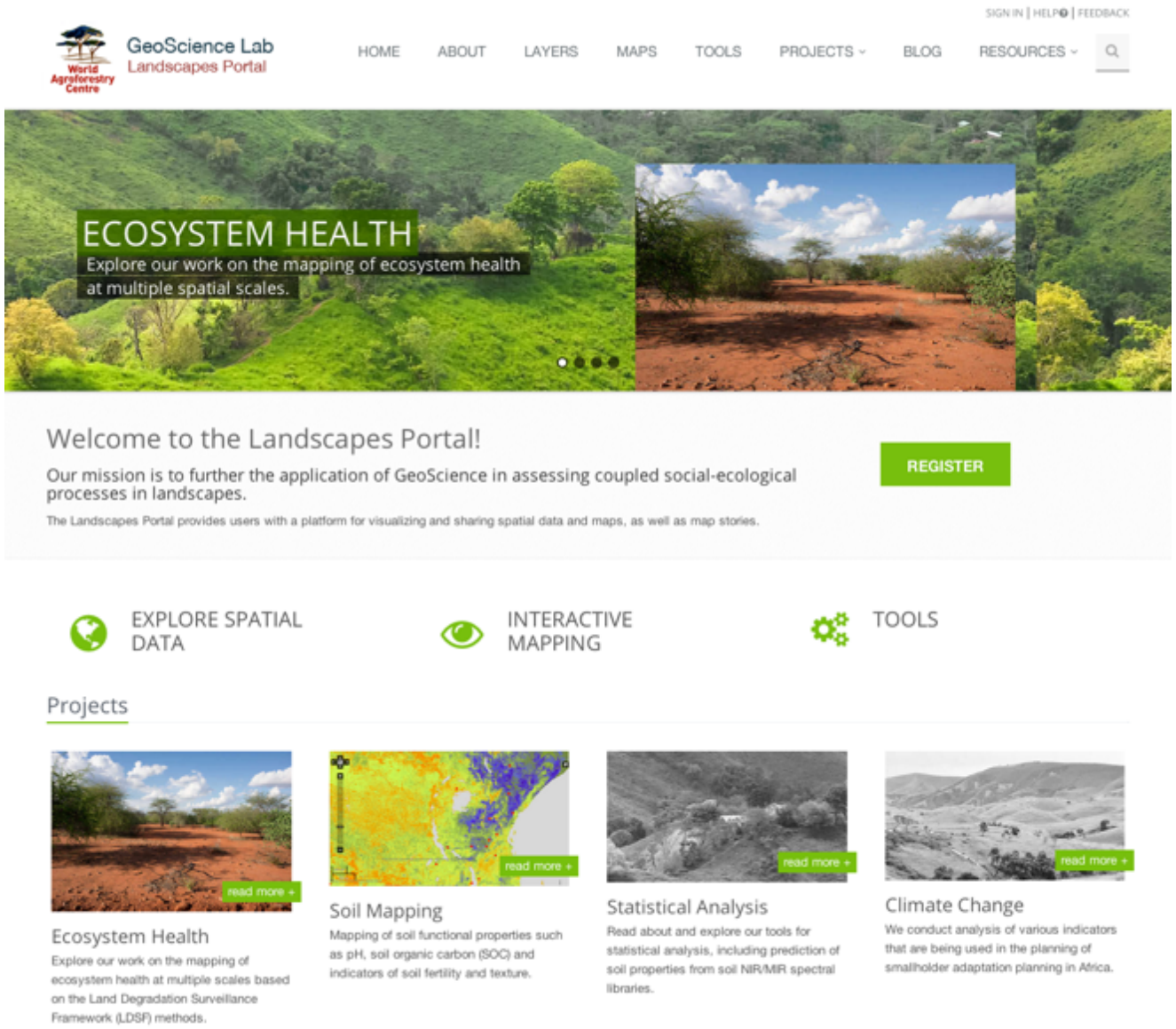
There is a need for research that incorporates multiple scales and perspectives

Understanding variation across various spatial scales

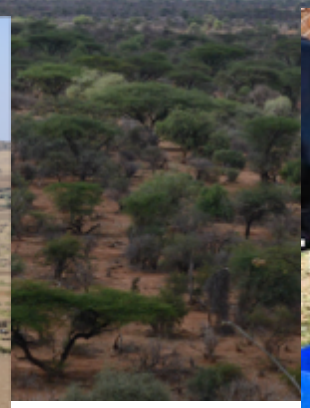


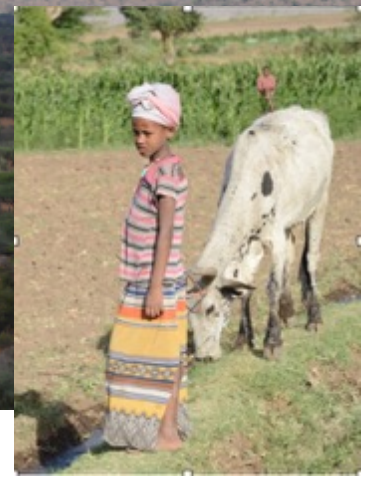
Vågen et al., 2016

ICRAF GeoScience Lab: landscapeportal.org



What works where, for whom?
'Options by Context'

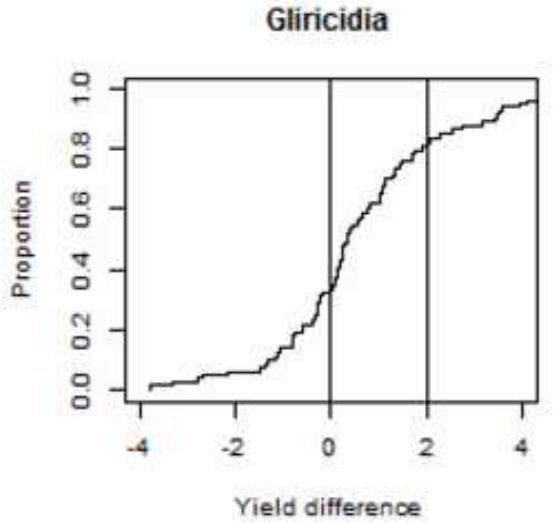



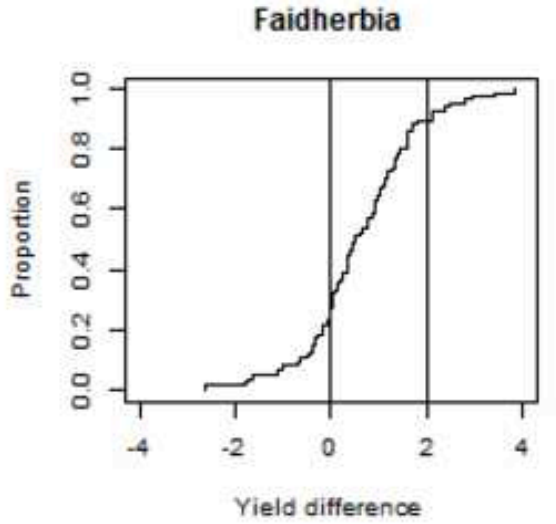
Understanding local context and developing and testing options across the various social-ecological environments

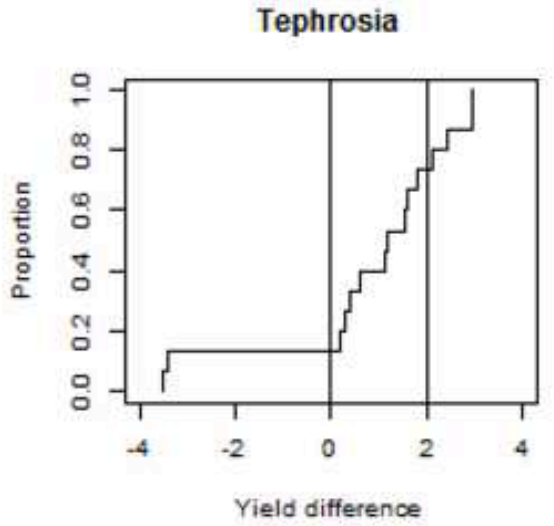
- Integrating biophysical and socio-economic datasets
- Planned comparisons
- Engagement with development partners (RinD)

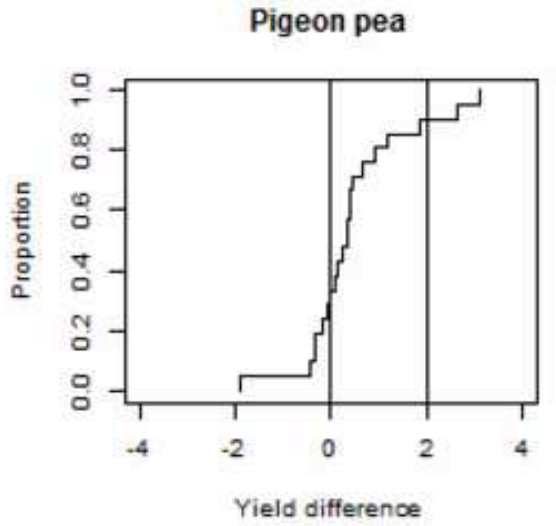
www.worldagroforestry.org/project/restoration-degraded-land-food-security-and-poverty-reduction-east-africa-and-sahel-taking

Teasing out agroforestry options for different contexts: co-learning



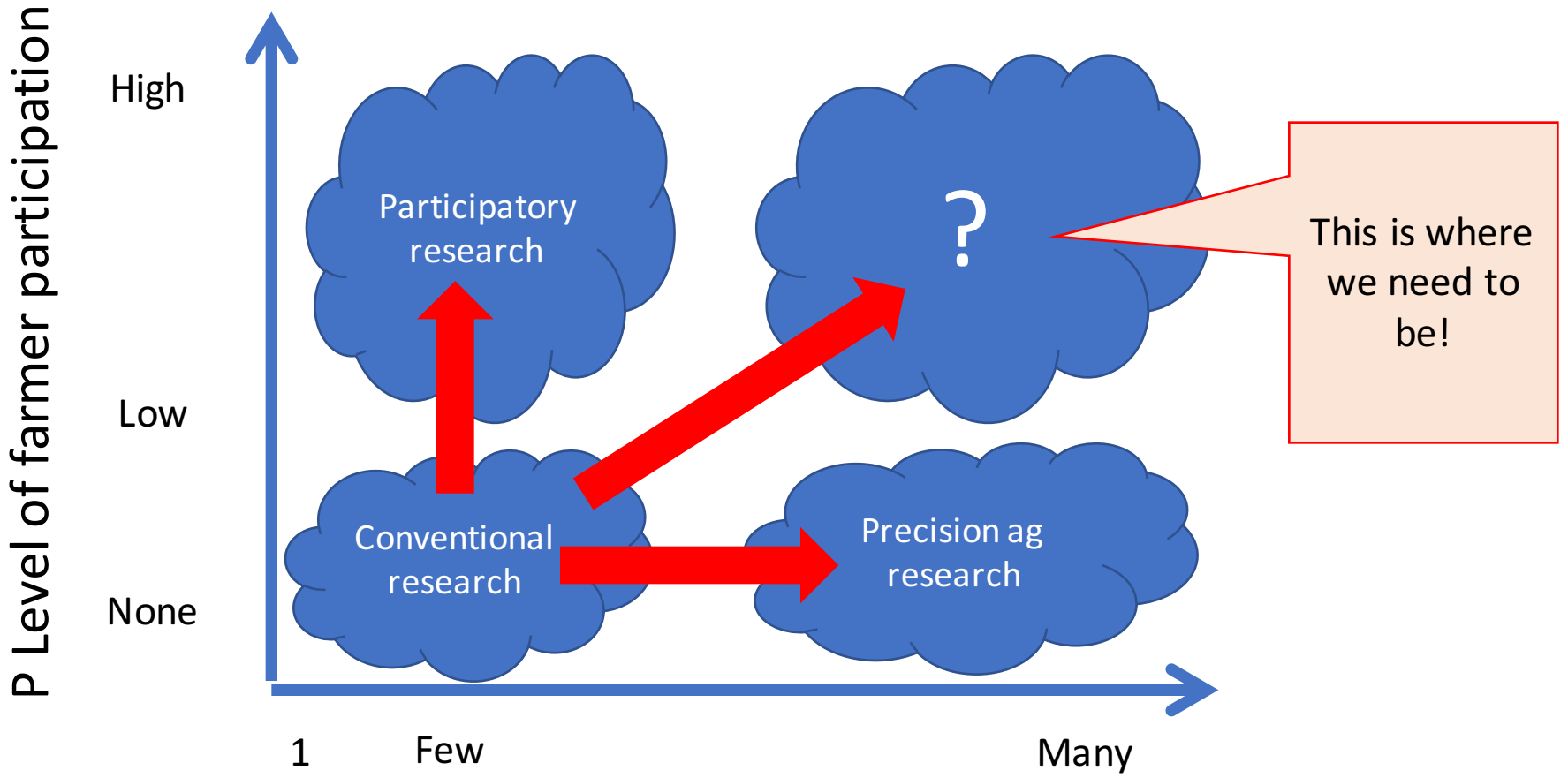






Coe R, Njoloma J and Sinclair FL. 2016. Loading the dice in favour of the farmer: reducing the risk of adopting agronomic innovations. *Experimental Agriculture*.

The N x P space of research methods



N number of sites/participants

≈c exp(number of environment/context factors)

Slide Courtesy:
Ric Coe

Sustainable Agricultural Intensification (SAI) – Key Researchable Issues

- Ecosystem service trade-offs and synergies
  - Impacts of land use change on multiple ES
  - Scale and resolution of tools to assess and map ES
  - Shift from decision to negotiation support (bringing GIS tools and participatory processes together – multiple and competing knowledge systems – local, scientific, policy)
- The transformative power of trees and livestock
  - Soil biota, non responsive soils in Africa, cusp of scientific revolution with genomics (move from trees associated with higher abundence and activity of beneficial organsims to density and diversity required to achieve specific soil health outcomes on
  - Integrated systems, climate change adaptation AND mitigation
  - Nutrient flows (livestock) – manure is more important than milk and meat
- Systems research at the scale of impact
  - Testing and adapting options across fine-scale variation in context
  - Expanding options (technology, extension system / market interventions, policy and institutions)
  - Quantifying *diversity – resilience* linkages (variety of (orphan) crops and trees (many native) to suit different field, farm and landscape niches

Thank you!

http://www.worldagroforestry.org/

f.sinclair@cgiar.org