

Social actors and unsustainability of agriculture

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Social actors can strongly affect the sustainability of agricultural operations by influencing farmers' decisions and choices. Such actors include: (1) loss-making investors who abandon farms due to low returns, (2) angry neighbours negatively affected by farming operations and engaging in silent or active conflict, (3) dissatisfied customers at the end of the value chain who reject the products and shift to alternative providers, and (4) overacting regulators who over-regulate farm activities. A higher order sustainability concept considers the ability of farms to adapt and learn from early signs of threats. A number of response paths based on policies, incentives and information supply have been developed to support learning and adjustments. Emphasis on the nested-scales relations of incremental sustainability and sustainability, in addition to the more commonly articulated ecological threshold perspective, helps identify key indicators that characterize unsustainability processes across countries and contexts. A dynamic systems understanding also assists selection of process indicators focused on response paths that complement result-oriented approaches in current sustainability assessment frameworks.

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Introduction

The sustainability debate in agriculture arose from the perception that many agricultural systems, in various combinations of issues, are harmful to the environment, threaten farming livelihoods or damage the social fabric of

rural areas. There is no shortage of sustainability assessment frameworks, most often revolving around the concept of result-oriented indicators to measure and monitor agricultural sustainability (e.g. [1–4,5*,6]). Some are framed vis-à-vis a normative (absolute) system of reference, others define threshold values within the current 'management swing potential' or relative to the difference between best and worst current practice [7*]. The debate typically follows an issue cycle [8] where cause-effect relations that play a role in early stages of the contest, are less important later on when indicators are selected for ease of assessment of compliance [9]. Indicator frameworks often focus on ecological aspects, sometimes complemented by economic indicators, and to a lesser extent by social indicators. The number of indicators varies widely, between ten or less [5*,10] to more than fifty [4,11], with indicators occasionally summarized into a single number for planet, people and profits [12**]. Given that agricultural systems are embedded in wide social institutional networks that influence their way of operating and consequently their impacts on sustainability, a truly integrative assessment of agricultural sustainability must consider potential threats emanating from social actors as an essential part of the evaluation. Thus, we first characterize unsustainability of agriculture and farming through an analysis of the diverse scales and social actors involved in agriculture and the ways in which their actions can threaten farm sustainability as part of socio-ecological systems. We then explore what feedback mechanisms are available for tackling these challenges to sustainability by influencing social actors.

Actors in agricultural landscapes whose actions can threaten farm sustainability

Lack of sustainability as reflected in existing sustainability frameworks that we reviewed can be linked to challenges to any of the various roles that agriculture and farming play (Table 1). Unsustainability can derive from the way soil, water, nutrients and biota are handled on farm [13], but it can also be expressed and voiced by social actors that are essential to the farm [14]. These actors include those affected by lateral flows that originate on farm (broadly speaking neighbours and environmental activists). They also include those providing essential inputs (including investment), and the customers of farm outputs, directly or indirectly via a value chain, with intermediate stakeholders. Beyond inputs and outputs, the farm also critically depends on the regulatory environment in which it operates. The regulatory environment is

Table 1

Aspects of farms and associated potential sources of unsustainability

Aspects of dynamic farms	Potential cause of unsustainability
Solar energy converters, linking C, N, P and water cycles and lateral flows	Loss of primary productivity, interrupted nutrient cycles and water flows, depleted soil carbon stocks, loss of soil structure and biota
Enterprises that use land, labour, knowledge, germplasm and capital in production	Loss of any of the key production factors, for which more profitable uses may arise from new economic opportunities
Starting points of value-chains that feed the world and satisfy part of its fibre and fuel requirements	Loss of demand for products, for example due to concerns over product quality and/or quality of the production process
Part of social networks	Conflict and loss of collective action
A component of larger household livelihood systems	Loss of complementarity with other parts of livelihood systems and evolving ambitions
Links in intergenerational knowledge chains that combine informal and formal science	Loss of relevance of existing knowledge under new circumstances, dominance of external, formal knowledge, loss of effective intergenerational transmission and learning
Part of landscapes	Conflicts over lateral flows such as water, nutrients, soil, organisms or fire and integral landscape functions such as perceived beauty
Agrobiodiversity management units, involved in selective reproduction of crops, livestock and trees making them drivers of inter- and intraspecific genetic diversity trends	Lack of adaptive capacity of farm-level germplasm in the face of new challenges (pests and diseases, climate change, shifting market demands), lack of access to external germplasm

itself influenced by the opinions of investors, neighbours/activists and value-chain-operators, without necessarily addressing all their concerns. Without being comprehensive in listing all actors related to farming and food systems these kinds of threats to sustainability of farm-level operations can be broadly described by considering the following four groups of social actors (Figure 1):

- (1) Loss-making investors and credit providers who abandon farms due to low economic returns,
- (2) Angry neighbours and environmental activists engaging in silent or active conflict, because they are negatively affected by farming activities, for example, through pesticide-contaminated water running off the farm,
- (3) Dissatisfied customers at the endpoint of value chains who do not trust the quality of products or disapprove of production conditions and shift to alternative providers,
- (4) Overacting regulators who over-regulate farm activities.

Many actors that fall under the categories listed above may exert both negative and positive influences on different aspects of sustainability. For example, dissatisfied customers asking for environmentally friendly products may pose an economic challenge to farms but ultimately lead to reduced environmental externalities. Yet because such demands may require farms to deviate from their traditional practices, a step that often involves substantial risks, we consider them here as potential threats to the sustainability of a farming operation.

On top of threats for farm sustainability stemming from these actors, it is well recognized that depletion of essential production resources, a common result of unsustainable practices, as well as lack of options to respond to new

conditions and challenges are also major threats for farm sustainability.

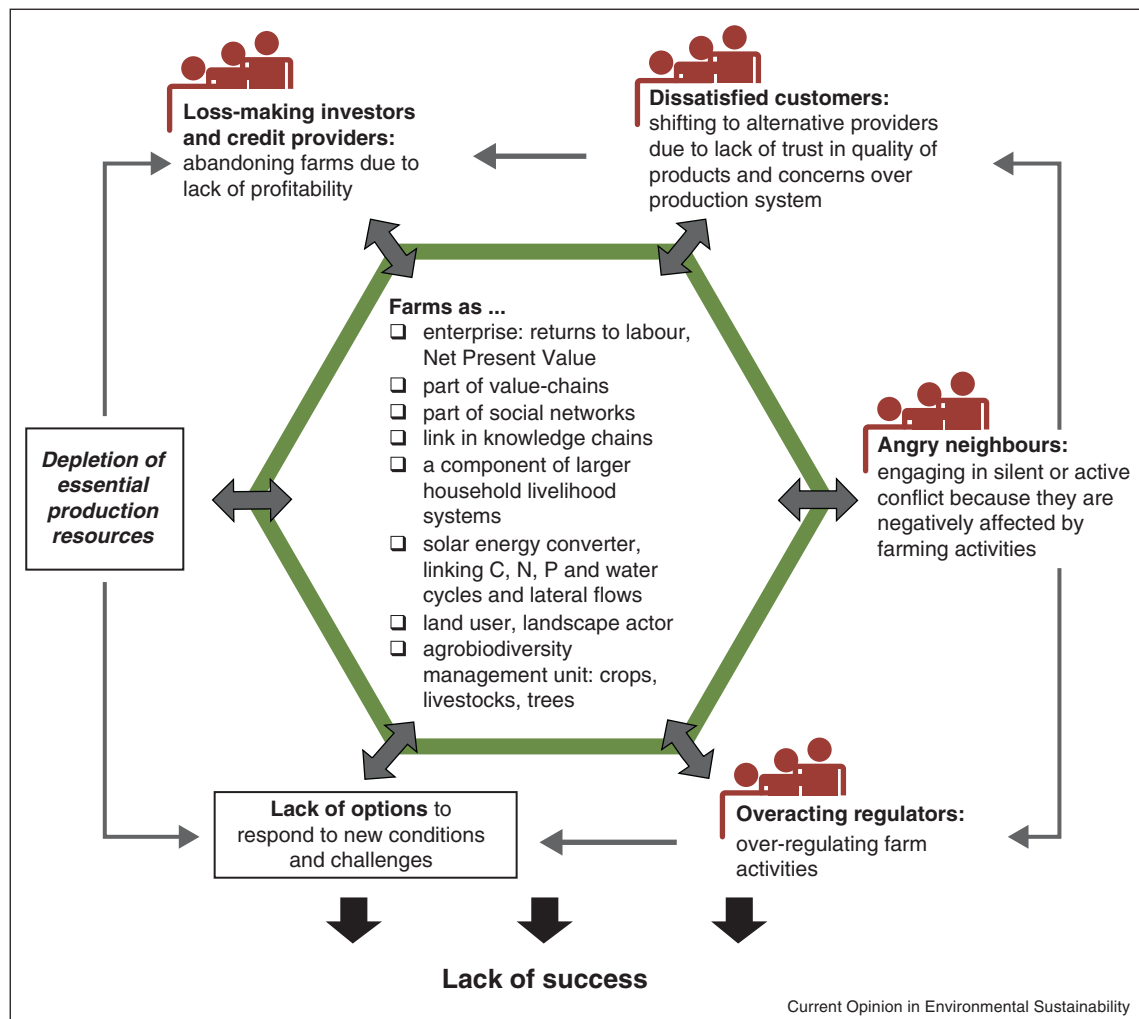
According to each actor's contexts, they perceive their actions as sustainable. Hence, they influence how farmers make management decisions to negotiate immediate pressures and plan for future change. All actors' decisions and choices can render an agricultural operation unsustainable — a quality that often manifests itself in farmers failing to meet their (social and/or financial) objectives. Once other options exist in society, it can become difficult to find successors who are willing to continue with the farm, as ultimate sustainability challenge.

Characterizing unsustainability of agriculture: actor-based indicators

This analysis suggests a number of indicators that characterize unsustainability of agriculture resulting from key actors' decisions, choices and interactions with farms. Examples of such indicators which can be used across countries and contexts are found in Table 2. These indicators can facilitate review of the current state of interplay of agriculture and farming from a social actor point of view and identify major threats. For some indicators, there may be thresholds from an actor perspective (acceptable/unacceptable; 'in' versus 'out'). For others, quantitative and/or qualitative interpretation will guide learning and adaptive responses.

Different actors have their own specific interests that sometimes contrast and often compete, and they may emphasize different indicators of unsustainability for various reasons. Additionally, each actor may experience internal conflicts of interest which may result in modified preference of indicators. Likewise, some actors may be more powerful than others to lobby for their interests, and, thus, put stronger weights on different indicators.

Figure 1



Interactions that can lead to unsustainability based on farm functions listed in Table 1 (modified from [14,13]).

What key interventions can influence social actors' behaviour?

Sustainability of farming and thus of agro-ecosystems depends on the ability of farmers to overcome current and future threats. Hence opportunities for continued change, which enable farmers to adapt and meet their needs in new ways (sustainability), are vital for shifting the debate from the static concept of resilience to the dynamic idea of adaptive management [16]. We review the major current approaches to socio-economic sustainable intensification and highlight some challenges and opportunities for a more iterative process. Tracking incremental changes in states along the suggested pathways can convey the adaptive capacity needed to reach more sustainable agricultural outcomes. Appropriate indicators for assessing progress along these pathways provide actionable information for decision-makers and practitioners and can be key tools in facilitating effective

management. Such process indicators also help prevent the pathways from becoming a mere list of intentions. Examples of potential indicators can be found in Table 3.

Reforms of macro-economic policies and integration of sectoral policies

Farm profitability responds to fluctuations of input and commodity prices and availability, variation in prices of external inputs and labour, and government taxes and subsidies. For instance, studies suggest that low-cost and beneficial pathways towards sustainable land use at the national scale can be achieved through economic policy reform such as carefully targeted shifts in subsidy priorities and reduced import tariffs and export taxes [17,18]. Furthermore, promoting availability of long-term credit will support farmers to shift from short-term to long-term agricultural investments. Sectoral policies can also be a strong lever for influencing farmer behaviour, but they

Table 2

Indicators for characterizing unsustainability of agriculture resulting from key actors' decisions, choices and interactions with farms

Key actors with potential to cause unsustainability	Indicators	Possible metrics
Loss-making investors and credit providers	Economic bottom line Opportunity costs of options foregone Risk quantifiers	Rate of return on investment Input/output accounting Known risks Guesstimated level of uncertainty
Angry neighbours	Conflicts over water use Conflicts over pollution (water, atmosphere, noise, haze and similar lateral flows) Conflicts over landscape beauty Conflicts caused by agricultural practices (e.g. free grazing, fire setting, poor soil conservation practices)	Number of conflicts that are reported in media, and/or reach local or national parliaments Number and type of monitoring systems that is set up to clarify and quantify issues Number of negotiated agreements
Dissatisfied customers	Emergence of new issues of consumer concern Shifts to alternative providers Responsiveness of producers to consumer concerns Development of certification schemes that address consumer concerns	Shifts in market shares Number of dialogues between producers and consumers Market share of certified products and price differential in relation to transaction costs
Over-acting regulators	Complexity and costs of procedures needed for permits for resource access and use Absence, inadequacy or outdatedness of development and land use plans Biased/top-down economic and development instruments (e.g. subsidies, taxes)	Transaction costs and time required for clearance Land use plan, its scope, origin and enforcement Number of negotiated agreements in multistakeholder fora
Farmers without options to respond to new conditions and challenges	Number of farms that are not sustained intergenerationally Rural-urban migration of youths	Inter-generational reduction in number of active farms Land conversion to non-agricultural functions

often lack coherency and integration. For example, current policies on food crops, forests and agroforestry are often poorly integrated. Inclusion of indigenous high-value timber into maize farming in the Philippines was, at current farm gate prices, only just economically feasible, while it reduced economic risk at farm level [17^{*}]. When profitability was evaluated with the social price vector, referring to the national economy, it was twice as high as continued maize monocultures. Substantial benefits for the national economy apparently remained mostly unrealized, because agricultural policies favoured maize (food) over wood production, providing a disincentive to integrating trees on farms.

Participatory land-use planning and social learning

Agricultural land use can cause great environmental change to the biosphere in terms of below-ground and above-ground lateral flows of water, nutrients, soil and organisms [15], which can lead to conflicts among neighbours. Due to the many competing uses for land, specific zoning is needed for efficient management of agricultural expansion. However, even with successful planning at the

landscape level, new policies can create changes in rules or regulations related to tenure rights and access to water and other resources that result in adverse effects for farmers. This emphasizes the need for a balance between credibility and legitimacy of land use plans [19^{**}]. Relevant input related to social or cultural priorities may be distinctly 'a-spatial' or not articulated in spatial terms [20]; therefore incorporating stakeholders' preferences and perceptions in land use planning (so-called participatory land use planning) can achieve increased levels of sustainability [19^{**},21^{*}]. While stakeholder participation is a necessary condition, it is not a sufficient one [22] to *ipso facto* guarantee better practices [23], and attention has shifted to social learning as a key approach [24]. Reed *et al.* [22] recently defined social learning as 'a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice through social interactions between actors within social networks.' Innovative approaches such as multi-agent simulation coupled with role-playing games are now being tested to integrate decision making and preferences of local actors in the agricultural

Table 3

Process indicators to track progress along response paths

Key pathways	Proposed indicators and metrics
Reforms of economic policies and integration of sectoral policies	Number of measures that reduce or eliminate market distortions Amount of long-term credit given
Participatory land use planning and social learning	Number of stakeholder engagements in land use planning using multi-agent simulation and/or role-playing games or other participatory approaches
Value chain and trade sustainability	Amount and percentage of land under different forms of sustainable agriculture (organic, fair, landscape labelling, etc.) Number and type of certified products
Financial incentives: payments for environmental services	Number and/or existence of national policies that promote PES in agriculture Percentage of PES revenue among total farm income
Effective extension	Number of innovation platforms Number of farm group memberships or cooperatives

landscapes for understanding and visualizing interactions in social–ecological systems and choosing between alternative future landscapes [19^{••},21[•]].

Financial incentives: payments for environmental services

Management practices influence the potential for provision of environmental services or disservices through agriculture [25]. In order to influence farmers' decisions in ways that avoid depletion of natural resources and favour the delivery of environmental services, natural capital accounting is key to internalize the positive externalities created by agricultural landscapes. Schemes such as Payment for Environmental Services (PES) can be used to compensate farmers for their opportunity costs or foregone benefits from land development [26^{••},27], as well as reward them for their efforts in land management, maintenance of vegetative cover, carbon sequestration and agrobiodiversity conservation. This can also improve livelihoods of the rural poor. In a review of fifty tree-based PES projects in Africa, Namirembe *et al.* [28] found that flexible co-investments may be better suited for most African farmers, who are often too poorly connected to markets to realistically benefit from strictly commoditized PES schemes.

Value chain and trade sustainability

Sustainable agricultural supply chains demand for greater production and/or higher agricultural productivity while at the same time achieving improved environmental, economic, and social outcomes. Certification schemes or standards that involve specified indicators/criteria of sustainability can offer incentives to investors and producers in the form of growing niche markets, greater market access, higher buying prices or protected reputations [29]. They can also respond to widespread consumer concerns regarding product quality, resource use, environmental quality and social equity issues [18].

However, a number of challenges remain, such as inadequate prices for certified products, which do not always compensate for smallholders' production constraints [30] and the potential failure of globally applied production standards to address site-specific sustainability concerns [31]. Standards are useful, but they do not raise the bar for all practices. A much broader impact on sustainability can be achieved by promoting globally the use of sustainability standards to all agricultural commodities [32,33]. In the same vein, another interesting option is landscape labelling, in which certification labels are not restricted to particular products but distinguish all outputs from a particular landscape. This practice could specifically benefit smallholders within the landscape mosaics often encountered in developing countries [34[•]].

Effective extension

Strengthening agricultural extension services for farmers and their supply-chain partners is critical for transferring technology to cope with change and maintain sustainable farming systems [18]. Recently, the use of innovation platforms for dissemination of agricultural technologies has been considered more effective in achieving sustainability than classic farmer-researcher-extension approaches. The main working concept is initiation of a two-way communication mechanism amongst researchers, extension agents and farmers. In this conversation, constraints to technological innovations are identified, and best-fit options are determined and supported for wider use [35,36]. Innovation platforms include more players than traditional extension approaches (researchers, development agents, farmers, cooperatives, input and output traders and policy makers), allowing partnerships along the value chain to be established and cultivated [35,36]. Innovation platforms have been successfully implemented in Ethiopia for the effective diffusion of grain legumes [37] and in Malawi for evaluating and scaling-up of

best-fit integrated soil fertility management technologies [35,36]. There have been many efforts to develop and promote specific agricultural practices such as conservation agriculture, evergreen agriculture [38], climate-smart agriculture [39] or agroforestry [40] as being sustainable. The empirical reality of smallholder farmers may differ from the sustainability recommendations, however [41,42^{*}]. Recent debates on ‘contested agronomy’ further strengthen a ‘Nullius in verba’ (don’t take anybody’s word for it) distrust of external expertise and sustainability recipes [43,44,45]. Consequently, new multistakeholder negotiation platforms have emerged as ‘roundtables’ such as the one for palm oil sustainability. Ultimately the way debate is maintained as a commitment to learning by all is more important than the specific standards that have so far emerged.

Conclusion

A remaining challenge for all work on sustainability indicators is to move beyond persistence considerations and embrace change, as the ‘sustainability’ concept attempts [26^{**}]. Where change in socio-ecological systems is achieved by negotiations among stakeholders [46], the role of expert advice is changing [47] and in terms of change and learning, bottom-up, integrated participatory or transdisciplinary methods provide the most meaningful agricultural sustainability assessment [48]. In a hierarchy of leverage points that can change systems behaviour [49], data and values for thresholds, taxes and incentives come at the bottom, followed by properties of the dynamic feedback, its lag time and buffering, the information flows and rules of the game and the power to add, change, evolve, or self-organize system structure. Even more influential are the goals of the system and the mindset or paradigm out of which the system (with its goals, structure, rules, delays, feedbacks and parameters) arises. Beyond that is only the power to transcend paradigms. Overcoming systemic roadblocks to sustainability requires an evolutionary redesign of world-views, institutions, and technologies [50]. No checklist of criteria and indicators can achieve that, but the many pathways to unsustainability are now better recognized, and each can be a trigger of change in working towards sustainable multifunctional agriculture.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
 - of outstanding interest
1. Dantsis T, Douma C, Giourga C, Loumou A, Polychronaki EA: **A methodological approach to assess and compare the sustainability level of agricultural plant production systems.** *Ecol Indic* 2010, **10**:256-263.
 2. Florin MJ, Van Ittersum MK, Van De Ven GWJ: **Selecting the sharpest tools to explore the food-feed-fuel debate: sustainability assessment of family farmers producing food, feed and fuel in Brazil.** *Ecol Indic* 2012, **20**:108-120.
 3. Gómez-Limón JA, Sanchez-Fernandez G: **Empirical evaluation of agricultural sustainability using composite indicators.** *Ecol Econ* 2010, **69**:1062-1075.
 4. Pelzer E, Fortino G, Bockstaller C, Angevin F, Lamine C, Moonen C, Vasileiadis V, Guérin D, Guichard L, Reau R *et al.*: **Assessing innovative cropping systems with DEXiPM, a qualitative multi-criteria assessment tool derived from DEXi.** *Ecol Indic* 2012, **18**:171-182.
 5. Reidsma P, König H, Feng S, Bezlepina I, Nesheim I, Bonin M, Sghaier M, Purushothaman S, Sieber S, van Ittersum MK *et al.*: **Methods and tools for integrated assessment of land use policies on sustainable development in developing countries.** *Land Use Policy* 2011, **28**:604-617.
- This study develops a methodological framework for impact assessment of land use policies on sustainable development, with combination of quantitative and qualitative approaches. This study provides a comprehensive illustrative case-study from China.
6. Reig-Martínez E, Gómez-Limón JA, Picazo-Tadeo AJ: **Ranking farms with a composite indicator of sustainability.** *Agric Econ* 2011, **42**:561-575.
 7. Davis SC, Boddey RM, Alves BJR, Cowie A, Davies C, George B, Ogle SM, Smith P, van Noordwijk M, van Wijk M: **Management swing potential for bioenergy crops.** *Global Change Biol Bioenergy* 2013.
- This study reviews the greenhouse gas balance and ‘management swing potential’ of seven different bioenergy cropping systems in temperate and tropical regions.
8. Tomich TP, Chomitz K, Francisco H, Izac AM, Murdiyarso D, Ratner B, Thomas DE, Van Noordwijk M: **Asking the right questions: policy analysis and environmental problems at different scales.** *Agric Ecosyst Environ* 2004, **104**:5-18.
 9. Hayati D, Ranjbar Z, Karami E: **Measuring agricultural sustainability.** In *Biodiversity, Biofuels, Agroforestry and Conservation Agriculture*, vol 5. Edited by Lichtouse E. Sustainable Agriculture Reviews; 2010:73-100.
 10. Sattler C, Nagel UJ, Werner A, Zander P: **Integrated assessment of agricultural production practices to enhance sustainable development in agricultural landscapes.** *Ecol Indic* 2010, **10**:49-61.
 11. Rodrigues GS, Rodrigues IA, Buschinelli CCdA, de Barros I: **Integrated farm sustainability assessment for the environmental management of rural activities.** *Environ Impact Assess Rev* 2010, **30**:229-239.
 12. Griggs D, Stafford-Smith M, Gaffney O, Rockström J, Öhman MC, Shyamsundar P, Noble I: **Policy: sustainable development goals for people and planet.** *Nature* 2013, **495**:305-307.
- This study develops a set of six sustainable development goals from combining the Millennium Development Goals with conditions necessary to assure the stability of Earth’s systems.
13. Hairiah K, van Noordwijk M, Weise S: **Sustainability of tropical land-use systems following forest conversion.** In *Slash and Burn: The Search for Alternatives*. Edited by Palm C, Vosti S, Schroeder P, Ericksen P, Juo A. Columbia University Press; 2005: 548-602.
 14. Van Noordwijk M, Cadisch G: **Access and excess problems in plant nutrition.** *Plant Soil* 2002, **247**:25-39.
 15. Van Noordwijk M, Poulsen J, Ericksen P: **Filters, flows and fallacies: quantifying off-site effects of land use change.** *Agric Ecosyst Environ* 2004, **104**:19-34.
 16. Jackson L, van Noordwijk M, Bengtsson J, Foster W, Lipper L, Pulleman M, Said M, Snaddon J, Vodouhe R: **Biodiversity and agricultural sustainability: from assessment to adaptive management.** *Curr Opin Environ Sustain* 2010, **2**:80-87.
 17. Santos-Martin F, van Noordwijk M: **Is native timber tree intercropping an economically feasible alternative for smallholder farmers in the Philippines?** *Aust J Agric Resour Econ* 2011, **55**:257-272.
- This study assesses whether intercropping systems with native species are an economically feasible alternative to maize monocropping or to intercropping with exotic species for smallholder upland farmers in terms of: (i) profitability, (ii) labour requirements, (iii) economic risk and (iv) current and potential future policy regimes on prices, taxes, market access and input subsidies.

18. United Nations Environment Programme (UNEP): **Agriculture: investing in natural capital. Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication.** 2011.
19. Bourgoin J, Castella JC, Pullar D, Lestrelin G, Bouahom B: **Toward a land zoning negotiation support platform: “tips and tricks” for participatory land use planning in Laos.** *Landsc Urban Plan* 2012, **104**:270-278.
- This study shows how visualization and learning boundary tools can help translate participatory principles into reality by empowering local people in designing future land use plans and by acting as catalysts of negotiation.
20. Ban N, Mills M, Tam J, Hicks C, Klain S, Stoeckl N, Bottrill M, Levine J, Pressey R, Satterfield T: **A social-ecological approach to conservation planning: embedding social considerations.** *Front Ecol Environ* 2013, **11**:194-202.
21. Villamor G, van Noordwijk M: **Social role-play games vs individual perceptions of conservation and PES agreements for maintaining rubber agroforests in Jambi (Sumatra), Indonesia.** *Ecol Soc* 2011, **16**:27.
- Results revealed a strong conservation belief system and social norms in the research site, with indications that individual interest in converting old rubber agroforest to oil palm, with consequent private gain and loss of local social agrobiodiversity benefits, is suppressed in the social context of a role-playing game.
22. Reed M, Evelyn G, Cundill I, Fazey J, Glass A, Laing J, Newig B, Parrish C, Prell C: **What is social learning?** *Ecol Soc* 2010, **15**.
23. Scott A: **Focussing in on focus groups: effective participative tools or cheap fixes for land use policy?** *Land Use Policy* 2011, **28**:684-694.
24. Schwilcha G, Bachmann F, Valenteb S, Coelhob C, Moreirac J, Laouinad A, Chakerd M, Aderghald M, Santose P, Reed M: **A structured multi-stakeholder learning process for Sustainable Land Management.** *J Environ Manage* 2012, **107**:52-63.
25. Wei Zhang W, Taylor H, Ricketts T, Claire Kremen C, Karen Carney K, Swinton S: **Ecosystem services and dis-services to agriculture.** *Ecol Econ* 2007, **64**:253-260.
26. Jackson L, Pulleman M, Brussaard L, Bawa K, Brown G, Cardoso I, De Ruiter P, Garcia-Barrios L, Hollander A, Lavelle P *et al.*: **Social-ecological and regional adaptation of agrobiodiversity management across a global set of research regions.** *Global Environ Change* 2012, **22**:623-639.
- This study identifies factors important for increasing agrobiodiversity and ecosystem services across an agricultural landscape in eight landscapes across five continents and suggests ways for local decision-making to be better integrated into the global agenda for ecosystem services and land stewardship.
27. van Noordwijk M, Leimona B, Jindal R, Villamor GB, Vardhan M, Namirembe S, Catacutan D, Kerr J, Minang PA, Tomich TP: **Payments for environmental services: evolution towards efficient and fair incentives for multifunctional landscapes.** *Annu Rev Environ Resour* 2012, **37**:389-420.
28. Namirembe S, Leimona L, van Noordwijk M, Bernard F, Bacwayo E: **Co-investment paradigms as alternatives to payments for tree-based ecosystem services.** *Curr Opin Environ Sustain* 2014, **6**:89-97.
29. Newton P, Agrawal A, Wollenberg L: **Interventions for achieving sustainability in tropical forest and agricultural landscapes.** *CAPRI Working Paper No. 110.* Washington, D.C.: International Food Policy Research Institute; 2013, .
30. Beuchelt T, Zeller M: **Profits and poverty: certification’s troubled link for Nicaragua’s organic and fairtrade coffee producers.** *Ecol Econ* 2011, **70**:1316-1324.
31. Luedeling E, Wichern F: **The need for site-specific adaptation of organic standards: the example of dryland salinity in Australia.** *J Agric Rural Dev Trop Subtrop Suppl* 2007, **89**:121-142.
32. Scarlat N, Dallemand JF: **Recent developments of biofuels/bioenergy sustainability certification: a global overview.** *Energy Policy* 2011, **39**:1630-1646.
33. Smith B: **Developing sustainable food supply chains.** *Philos Trans R Soc Lond B Biol Sci* 2008, **363**:849-861 <http://dx.doi.org/10.1098/rstb.2007.2187>.
34. Ghazoul J, Garcia C, Kushalappa C: **Landscape labeling approaches to PES: bundling services, products and stewards.** In *Payment for Ecosystem Services and Food Security.* Edited by Ottaviani D, Hage Scialabba N. Rome, Italy: FAO; 2011: 7-14.
- This work develops the concept of landscape labelling and highlights its advantages over current systems, as well as its potential disadvantages that remain researchable challenges for its implementation.
35. Kabambe V, Chilimba A, Ngwira A, Mbawe M, Kambauwa G, Mapfumo P: **Using innovation platforms to scale out soil acidity-ameliorating technologies in Dedza district in central Malawi.** *Afr J Biotechnol* 2012, **11**:561-5695.
36. Ngwira A, Kabambe V, Kambauwa G, Mhango W: **Scaling out best fit legume technologies for soil fertility enhancement among smallholder farmers in Malawi.** *Afr J Agric Res* 2012, **7**:918-928.
37. Abate T, Shiferaw B, Gebeyehu S, Amsalu B, Negash K, Assefa K, Eshete M, Aliye S, Hagmann J: **A systems and partnership approach to agricultural research for development: lessons from Ethiopia.** *Outlook Agric* 2011, **40**:213-220.
38. Garrity DP, Akinnifesi FK, Ajayi OC, Weldesemayat SG, Mowo JG, Kalinganire A, Bayala J: **Evergreen Agriculture: a robust approach to sustainable food security in Africa.** *Food Security* 2010, **2**:197-214.
39. Wollenberg E, Campbell BM, Holmgren P, Seymour F, Sibanda L, Braun JV: **Actions needed to halt deforestation and promote climate-smart agriculture.** *CCAFS Policy Brief* 2011:4. <http://hdl.handle.net/10568/10233> (assessed 20.12.13).
40. Mbow C, Neufeldt H, Van Noordwijk M, Minang P, Kowero G, Luedeling E: **Agroforestry solutions to address climate change and food security challenges in Africa.** *Curr Opin Environ Sustain* 2014, **6**:61-67.
41. Giller KE, Witter E, Corbeels M, Tittonell P: **Conservation agriculture and smallholder farming in Africa: the heretics’ view.** *Field Crops Res* 2009, **114**:23-34.
42. Baudron F, Tittonell P, Corbeels M, Letourmy P, Giller KE: **Comparative performance of conservation agriculture and current smallholder farming practices in semi-arid Zimbabwe.** *Field Crops Res* 2012, **132**:117-128.
- This study challenges the appropriateness for smallholder farms of widely recommended conservation agriculture practices based on farmer experience.
43. Sumberg J, Thompson J: *Contested Agronomy: Agricultural Research in a Changing World.* New York: Routledge; 2012, 220pp.
44. Sumberg J, Thompson J, Woodhouse P: **The changing politics of agronomy research.** *Outlook Agric* 2013, **42**:81-83.
45. Sumberg J, Andersson J, Giller KE, Thompson J: **Response to ‘Combining sustainable agricultural production with economic and environmental benefits’.** *Geograph J* 2012, **179**:183-185.
46. van Noordwijk M, Lusiana B, Leimona B, Dewi S, Wulandari D: *Negotiation-support toolkit for learning landscapes.* Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program; 2013, 285pp.
47. Stirling A: **Keep it complex.** *Nature* 2012, **468**:1029-1031.
48. Binder CR, Feola G, Steinberger JK: **Considering the normative, systemic and procedural dimensions in indicator-based sustainability assessments in agriculture.** *Environ Impact Assess Rev* 2010, **30**:71-81.
49. Meadows D: **Leverage points: places to intervene in a system.** *Solut Sustain Desir Future* 1999, **1**:41-49.
50. Beddoe R, Costanza R, Farley J, Garza E, Kent J, Kubiszewski I, Woodward J: **Overcoming systemic roadblocks to sustainability: the evolutionary redesign of worldviews, institutions, and technologies.** *Proc Natl Acad Sci* 2009, **106**:2483-2489.