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Transforming soils: transdisciplinary perspectives and pathways to sustainability

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Soils must be understood from a transdisciplinary perspective, integrating biophysical, social, economic and political understandings. This requires new combinations of methods. This paper introduces the STEPS 'pathways approach', which emphasises the importance of 'framing' of different options. Through a case study from Ethiopia, the possibilities of a transdisciplinary analysis of soils are explored. This highlights the importance of investigating the spatial patterning of nutrients in farm landscapes, and the social processes that influence why soils have different levels of fertility, as well as how local dynamics are influenced by wider policy framings. A set of participatory methods, including farm mapping, landscape level transect walks and biographical analysis of people and places, is discussed. These help broaden out analysis and open up debate, exposing alternative pathways to sustainability.

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Multi-faceted soils

Soils are at once biophysical, economic, social and political. We can understand soils from their chemical and physical composition, by measuring nitrogen, phosphorous, potassium and trace elements or assessing the amount of organic matter and their physical structure. We can understand them through their ecology, and the array of organisms making up the soil ecosystem. But beyond the technical understandings of soils, we must also see soils as part of socio-economic systems, and carrying political connotations.

Social perspectives on soils are important as we must understand soils as components of lived-in landscapes, part of variegated farms with different investments. Soils are not just passive substrates: they are created through labour, the addition of valuable inputs and the manipulation of their structure. Skill, expertise and much sweat and toil go into making a productive soil. Local nomenclatures for soils can be highly revealing, indicating a sense of a living, connected resource, so essential for survival [1–3]. Soil, water, climate, biodiversity all interact as part of a complex 'nexus' of resources required for food and water security.

Soils are of course also economic goods. Soil health is vital for production, income earning and the vitality of agriculture [4,5]. Different soils have different values because of the texture, fertility and location. Serious conflicts may arise when competition arises over access to soil resources. From colonial conquests to contemporary 'land grabbing', soils are at the heart of such processes [6••]. Rich alluvial deposits or fertile 'biochar' soils are inevitably in high demand [7].

Thus soils enter a political realm too, with competing discourses as to the status of soils and their value [8]. With policy narratives on soil degradation and desertification defining massive interventions by states and development projects, involving mobilisation of huge resources to create conservation structures, how soils are understood in policy has significant material implications [9].

A transdisciplinary 'pathways approach' for soils management

Too often ambitious attempts to improve soils for the betterment of agricultural production have failed when soil scientists have not interacted with others, most notably local people, who have other perspectives. This is why a transdisciplinary, complex systems perspective is essential. This requires viewing complex problems from different perspectives, and co-constructing solutions for sustainability across disciplines, but also crucially between researchers and wider stakeholders [10••,11,12••]. This paper makes the case for an approach based on the STEPS Centre's 'pathways approach', that pays special attention to the 'framing' of problems and solutions and the politics of knowledge in opening up and broadening out pathways to sustainability [13••], and examines its application in the context of Ethiopia.

In brief, the pathways approach starts with the assumption that the world is highly complex and interconnected, and different people, depending on their standpoint, position and interests, see this in different ways. Each of us 'frame' problems, and so solutions, differently. These framings often compete: some push some perspectives, others counter these. Exposing these framings and generating a debate about them is an essential first step.

From these framings, pathways to action emerge. Some may see sustainability simply as a challenge of adding more inorganic elements to the soil due to an assessment of nutrient deficits. Others may see the problem more as one of the social dynamics of production and the lack of labour to invest in soil improvement in particular patches of land. All perspectives are inevitably wrapped up in politics, and the interests that govern them. Interventions geared to fertiliser application may be supported by commercial companies and agencies that back them, or governments who gain favour through subsidy programmes [14]. Interventions at a farm scale may be influenced by resource access — perhaps manure through livestock ownership or communal grazing access or labour through gendered labour divisions — and so micro-politics at a household or community scale.

From these intersecting processes different pathways unfold. If the framing centres simply on soil nutrient deficits, then it is no surprise that interventions will focus on filling the identified gap; very often with the application of chemical fertilisers. However, if the framing focuses on the farm system, and the spatial pattern of soils and their fertility and their underlying social dynamics, then a different pathway may open up. Across the nexus of resources, and different priorities associated with food, energy and water security, a diversity of different perspectives and priorities will exist, requiring a negotiation between them.

Which pathway is chosen is down to politics: both the knowledge politics of what diagnosis is seen as most legitimate and valid, and carries with it the most authority and power, and also the interests that align behind the solutions. Always there are dominant and more peripheral, hidden pathways: none are necessarily the 'right' answer, but all emerge from a particular political economy of framing, policy-making and intervention.

Opening up choices and broadening out our analysis to multiple framings and viewpoints is thus central to the pathways approach [15••], as is the need to take on diverse perspectives from a transdisciplinary standpoint. Choices between pathways to sustainability and so the direction taken will have major implications for the distribution of benefits, costs and risks, as well as the diversity of socio-technical options chosen [16].

Pathways to soil improvement: the case of Ethiopia

Ethiopian agricultural and environmental policy highlights soil improvement/conservation as a major priority, and has done for many years. As a highly aid-dependent country, development agencies have often focused efforts on soils [17,18]. The environmental degradation narrative that underpins these actions argues that soil degradation, due to intensive farming and forest loss, is undermining agricultural productivity, especially in the highland areas where most poor smallholder farmers live [19].

This has to be countered, it is argued, by investment in soil and water conservation, including the digging of contour bunds, terracing and hillside closures to encourage revegetation. Over the years massive investments have occurred, often linked to major public works efforts supported by food aid. This has been combined with the promotion of 'package programmes', encouraging farmers to apply inorganic fertiliser, often supported by subsidised credit systems. Today, such programmes are supported by calls for 'climate smart' agriculture, with the additional benefits of soil conservation and revegetation being in terms of carbon sequestration and climate mitigation [34].

A top-down, large-scale, engineering-oriented approach to soil conservation has dominated, combined with a push for inorganic fertiliser as part of a 'Green Revolution' package [17,19]. The political, commercial and policy interests aligned to this pathway are considerable, backed by substantial resources. The Ethiopian state has seen the transformation of the agricultural sector as key to Ethiopia's future economic success. Drawing on the long tradition of soil conservation work, new energies have been put behind terracing and contour construction, often linked to 'climate smart' agriculture programmes.[1]

There is little doubt that soil health is a priority in Ethiopia. Long-term studies of erosion show that losses of soils are significant in the highlands without effective conservation measures. Equally, intensive agriculture on very small plots without soil fertility replenishment (as much manure is used for construction or fuel), results in depletion of soils. Often these are ancient farm lands with centuries of use, and extremely low productivity. This scientific understanding continues to be invested in, with projects underway to map soil fertility across the farming areas of the country.[2] The science is not in doubt, but we must ask whether it is always asking the right questions, and if not what other perspectives are being silenced or hidden.

[1] Such as the Sustainable Land Management Programme, supported by the World Bank, see: http://allafrica.com/stories/201312110849.html (accessed 15.10.14).

[2] http://www.ata.gov.et/projects/ethiopian-soil-information-system-ethiosis/ (accessed 17.10.14).

Asking different questions: a transdisciplinary approach

What then if different questions are asked, at different scales, on different topics, and of different people? Would we get the same answers, or would such an approach offer up alternative pathways of change?

In a study in the southern Ethiopian highlands, we tried to look at issues of soil fertility and management from a more local 'systems' perspective (see [3,20••,21–24]). This is a very particular farming system that combines grain crops with a perennial plant, enset (*Ensete ventricosum*, or 'false banana), with farming occurring often in very small plots [25]. We had a cross-disciplinary team, including an agricultural ecologist, a soil scientist, an economist, an anthropologist, and others, and we had access to soil laboratories for testing nutrient contents and organic matter. Crucially, our starting point for understanding system complexity was the perspective of farmers themselves — who after all have to manage such complexity on a day-to-day basis.

Our approach started with understanding the farming system, and how different parcels of land were used, and where different sources of fertility input were applied, and by whom. This required delving into the day-to-day practices of farming, the gender dynamics within households, the forms of cooperative arrangement at the community level (e.g. when looking at livestock herding, manure and communal grazing), and the institutional arrangements governing access to resources, including inorganic fertiliser via various government and NGO programmes.

Through document analysis and interviews, we also looked at the wider policy regimes, their changes over time and how they impinged on the local level. This was an area that has had its fair share of 'mainstream' interventions, framed by the sort of narratives discussed above. For many years, a large-scale integrated rural development programme (WADU, the Wolayta Agricultural Development Unit) had provided cheap or free fertilisers. This resulted in a major shift away from the enset cultivation system, as people found grain production easier. Fertiliser use (or 'addiction' as some farmers put it) increased between the earlier 1970s and the mid-1980s, and with this maize yields, as enset plantations and investment in gardening declined. In many ways, in the frame of the programme, this was a 'success'.

However, when the subsidies stopped, grain production collapsed (declining from a peak of 3.5 tonnes/ha to around 1–1.5 tonnes/ha; see [23]), and the fall-back safeguard of the enset plantations were no longer there. With a combination of poor rainfall and a dramatic series of pest attacks (notably bacterial wilt, *Xanthomonas campestris* pv. *musacearum*), the remaining enset plantations (now mostly on the larger farms) were hit further. This increased vulnerability to shocks, and in 2000, and again in 2003 and 2007, famines struck the area [26]. While of course not directly attributable to the ending of the fertiliser programme of WADU, the system shifts that this had precipitated a decade or more before were likely contributory factors. The point is not that inorganic fertilisers are inappropriate; far from it, they are essential, but they need to be advocated within a wider understanding of the system.

We also tried to understand soils through farmers' own cultural lenses, learning the local terminology for soil types and examining the multiple meanings. We also did extensive soil testing for nutrient content of different soils in samples of farms across transects from highland to (more) lowland, and between different patches within farms. Data were collected for basic modelling of erosion risks too. Land use and environmental histories were essential pieces of the jigsaw. Historical interviews traced the stories of particular plots of land, and the intimate social histories of soils and their use. Here issues of household gender dynamics, changing labour regimes, and the rise and fall of soil fertility in line with household fortunes were uncovered. 'Interviewing' a field or a plot, via its farmer interlocutors can be an incredibly revealing exercise, and was key to our 'system' level understanding.

This revealed a contrast between gardened areas near homes and fields further away. A major objective of all farmers was to increase the size of the gardened area ('*darkoa*') through intensive manuring and soil improvement through cultivation. Women were especially involved in these areas, and considerable labour — and skill — is invested in the gardens. These are areas where perennials are planted, including enset, but also trees, and complex intercropping systems that enhance soil structure and fertility are developed. Soil analyses showed positive nutrient balances in these sites, compared to the outfields (*shoka*), with nitrogen balances (N/kg/ha) ranging between −3.0 and 11.5 for richer farmers and −0.5 and −12 for poorer farmers in different garden areas, compared to −95 (richer farmers) and −54 (poorer farmers) for the outfields [22:72].

Informants told us of how in periods of plenty, the *darkoa* areas grew and food security was assured. These were times when labour was available at home, and people were not off seeking income elsewhere; when livestock populations grew and animals were healthy, and supplied more manure; and when grazing areas were plentiful and not enclosed by other villagers or by 'revegetation' projects, for example. Yet when misfortunes arose, through deaths or illnesses in the family, droughts or pest attacks, the *darkoa* shrank and food security was threatened. These complex dynamics were of course highly differentiated, and different people, depending on their wealth and asset ownership, told different stories about the soils in their fields.

Most *darkoa* areas are minute land parcels, of 0.1 ha or less, in total farm sizes ranging from 0.25 ha to 3.5 ha in the highland areas [22:68–9]. In large-scale mapping exercises of land use and soils, or in aggregated nutrient balance measures, based on undifferentiated sampling, they would be completely missed [27,28]. Scale and resolution are thus critical, and it is such 'key resources' (cf. [29]), that may be crucial to system functioning, and outcomes. The *darkoa* garden areas are of course only one part of people's land. Land sizes are again highly differentiated, with richer people having additional land beyond the gardens, whereas poorer people may have effectively none. These *shoka* areas, largely the preserve of men, are assumed by many to be 'the field', and where most intervention efforts are invested.

These are sites where fertiliser inputs are recommended, and where soil conservation measures are required. Depending on the asset base of the farmer, these interventions may or may not make sense. For richer farmers who can afford fertiliser on a regular basis, the farm production from these areas is crucial, and can result in surpluses for sale, and so a pattern of (male dominated) accumulation can occur, resulting in investments in livestock, implements and labour (and so increasing the *darkoa* garden). In such settings a virtuous circle is defined, although all farmers comment that their ultimate aim is to increase the *darkoa* garden area, and fertilisers are only a means to this end.

However for others, a focus on the outfield makes little sense. With little money and vulnerability to credit terms, risking everything on a maize crop depending on uncertain rainfall makes little sense. Many have adapted the 'package' recommendation to dose fertilisers in small amounts, plant by plant. With small land areas, the standard approaches are meaningless.

Thus a socially, culturally and spatially-attuned perspective on soils on farms over time reveals an important dynamic, never appreciated in standard interventions or aggregated assessments. It suggests a different pathway of change — and so very different intervention options, attuned to particular socio-economic circumstances, and land use and soil histories. This required a transdisciplinary approach using multiple methods in concert to reveal this dynamic.

This had not been part of the standard, mainstream approach. This often missed the mark dramatically, ignoring the key feature of the system (the garden areas), as these were beyond the gaze of the satellite images used for maps or were missed in sampling for nutrient assessments [30–32]. Understanding key resource use, and particularly the role of wetland or soil-enriched patches can transform the directions and focus of land use investments [29,33]. When ignored, this can result, as seen in Wolayta, in a fundamental undermining of system resilience through shifts in crops and land use. By contrast, our research revealed a pathway focused on investing in gardening, through composting, manure bulking and improvement, provision of tools and improved cultivation techniques linked to particular cropping combinations. Such an alternative pathway challenged the framing of the soil fertility challenge, and, through broadening out the analysis – notably through engaging with local farmers and their understandings - opened up a new set of social and biophysical challenges that only transdisciplinary team working, in partnership with land users, was able to offer. While some development interventions continue to frame the challenge in terms of standard, aggregate soil deficits, other initiatives have adopted an alternative frame highlighted by the research, more attuned to the way soil landscapes are used in the area.

Conclusion

Soils as a simultaneously biophysical, social, economic and political feature of complex systems have to be appreciated from different perspectives. Intervention in soil management is not just a case of improving N, P or K or creating a barrier to reduce erosion; it is much more than this. Understanding soils as part of a wider nexus of resources, in their social and political context, is crucial.

Yet too often transdisciplinary approaches are constrained. This occurs through a number of processes. For example, when scientific justifications, based on a particular, often narrow, set of disciplinary perspectives, dominate policy, and particular interests — including those of scientists with careers to make and papers to publish — overwhelm alternatives, there can be an extreme closing down of debate, and a limiting of pathways to a dominant, often narrow, if powerful, version. The lack of transdisciplinary training and wider professional, institutional and policy incentives often limit transdisciplinary science for sustainability.

Opening up debate to alternative pathways, and more diverse possibilities, requires a different type of science that is more transdisciplinary, and asks new and different questions. This requires shifts in the way institutions operate, training is carried out and incentives are managed. Opening up to alternative frames requires confronting the power of entrenched, incumbent professional and other interests. This can be challenging, but is key for effective research and development. Envisaging a future with a more transdisciplinary approach to soil management requires not only increase the array of skills and expertise in agricultural research institutions and extension agencies, but also encouraging new ways of working that focus in on how complex systems are understood from different perspectives. Accepting different ways of seeing the world may be uncomfortable and challenging, but is a critical ingredient of a more pluralistic approach to agricultural development that encourages multiple pathways towards sustainability. As the Ethiopia case study reveals, an integrated, systems-oriented, transdisciplinary approach, involving team work, and crucially a participatory, farmer-centred outlook, is essential if more sustainable pathways to soil health are to be realised.

References and recommended reading

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

•• of outstanding interest

1. Shipton P: **Land and culture in tropical Africa: soils, symbols, and the metaphysics of the mundane**. *Annu Rev Anthropol* 1994:347-377.
2. Sillitoe P: **Knowing the land: soil and land resource evaluation and indigenous knowledge**. *Soil Use Manage* 1998, **14**:188-193.
3. Dea D, Scoones I: **Networks of knowledge: how farmers and scientists understand soils and their fertility: a case study from Ethiopia**. *Oxf Dev Stud* 2003, **31**:461-478.
4. Chaparro JM, Sheflin AM, Manter DK, Vivanco JM: **Manipulating the soil microbiome to increase soil health and plant fertility**. *Biol Fertil Soil* 2012, **48**:489-499.
5. Tittonell P, Giller KE: **When yield gaps are poverty traps: the paradigm of ecological intensification in African smallholder agriculture**. *Field Crop Res* 2013, **143**:76-90.
6. •• White B, Borras SM Jr, Hall R, Scoones I, Wolford W: **The new enclosures: critical perspectives on corporate land deals**. *J Peasant Stud* 2012, **39**:619-647.
7. Leach M, Fairhead J, Fraser J: **Green grabs and biochar: revaluing African soils and farming in the new carbon economy**. *J Peasant Stud* 2012, **39**:285-307.
8. Blaikie P: *The Political Economy of Soil Erosion in Developing Countries*. Longman; 1989.
9. Keeley J, Scoones I: *Understanding Environmental Policy Processes: Cases from Africa*. Earthscan; 2003.
10. •• Brown K, O'Neill K, Fabricius C: **Social science understanding of transformation**. *Changing Global Environments. World Science Report 2013*. Paris: ISSC/UNESCO; 2013, .
11. Mauser W, Klepper G, Rice M, Schmalzbauer BS, Hackmann H, Leemans R, Moore H: **Transdisciplinary global change research: the co-creation of knowledge for sustainability**. *Curr Opin Environ Sustain* 2013, **5**:420-431.
12. •• Hackmann H, Clair ALS: *Transformative Cornerstones of Social Science Research for Global Change*. Paris: International Social Science Council; 2012.
13. •• Leach M, Scoones I, Stirling A: *Dynamic Sustainabilities: Technology, Environment, Social Justice*. London: Earthscan; 2010.
14. Chinsinga B: **Seeds and subsidies: the political economy of input programmes in Malawi**. *IDS Bull* 2011, **42**:59-68.
15. •• Stirling A: **'Opening up' and 'closing down' power, participation, and pluralism in the social appraisal of technology**. *Sci Technol Hum Value* 2008, **33**:262-294.
16. *STEPS Centre: Innovation, Sustainability, Development: A New Manifesto*. Falmer: STEPS Centre; 2010.
17. Hurni H: **Degradation and conservation of the resources in the Ethiopian highlands**. *Mountain Res Dev* 1988:123-130.
18. Nyssen J, Poesen J, Moeyersons J, Deckers J, Haile M, Lang A: **Human impact on the environment in the Ethiopian and Eritrean highlands: state of the art**. *Earth-Sci Rev* 2004, **64**: 273-320.
19. Keeley J, Scoones I: **Knowledge, power and politics: the environmental policy-making process in Ethiopia**. *J Modern African Stud* 2000, **38**:89-120.
20. •• Scoones I: *Dynamics and Diversity: Soil Fertility and Farming Livelihoods in Africa: Case Studies from Ethiopia, Mali, and Zimbabwe*. London: Earthscan; 2001.
21. Scoones I: **Seeing scarcity: understanding soil fertility in Africa**. In *The Limits to Scarcity: Contesting the Politics of Allocation.* Edited by Mehta L. London: Earthscan; 2010:165-179.
22. Konde A, Dea D, Jonfa E, Folla F, Scoones I, Kena K, Berhanu T, Tessema W: **Creating gardens: the dynamics of soil fertility management in Wolayta, Ethiopia**. In *Dynamics and Diversity: Soil Fertility and Farming Livelihoods in Africa: Case Studies from Ethiopia, Mali, and Zimbabwe.* Edited by Scoones I. London: Earthscan; 2001:45-77.
23. Elias E, Scoones I: **Perspectives on soil fertility change: a case study from southern Ethiopia**. *Land Degrad Dev* 1999, **10**: 195-206.
24. Scoones I, Toulmin C: **Soil nutrient balances: what use for policy?** *Agric Ecosyst Environ* 1998, **71**:255-267.
25. Alemu K, Sandford S: *Enset in North Omo. Technical Report, 1*. Addis Ababa: Farm Africa; 1991.
26. Handino M: *'Green famine' in Ethiopia: Understanding the Causes of Increasing Vulnerability to Food Insecurity and Policy Responses in the Southern Ethiopian Highlands*. . (Doctoral thesis) University of Sussex; 2014.
27. Mortimore M, Harris F: **Do small farmers' achievements contradict the nutrient depletion scenarios for Africa?** *Land Use Policy* 2005, **22**:43-56.
28. Cobo JG, Dercon G, Cadisch G: **Nutrient balances in African land use systems across different spatial scales: a review of approaches, challenges and progress**. *Agric Ecosyst Environ* 2010, **136**:1-15.
29. Scoones I: **Wetlands in drylands: key resources for agricultural and pastoral production in Africa**. *Ambio* 1991:366-371.
30. Zeleke G, Hurni H: **Implications of land use and land cover dynamics for mountain resource degradation in the Northwestern Ethiopian highlands**. *Mt Res Dev* 2001, **21**: 184-191.
31. Feoli E, Vuerich LG, Zerihun W: **Evaluation of environmental degradation in northern Ethiopia using GIS to integrate vegetation, geomorphological, erosion and socio-economic factors**. *Agric Ecosyst Environ* 2002, **91**:313-325.
32. Vågen TG, Winowiecki LA, Abegaz A, Hadgu KM: **Landsat-based approaches for mapping of land degradation prevalence and soil functional properties in Ethiopia**. *Remote Sens Environ* 2013, **134**:266-275.
33. Fairhead J, Scoones I: **Local knowledge and the social shaping of soil investments: critical perspectives on the assessment of soil degradation in Africa**. *Land Use Policy* 2005, **22**:33-41.
34. McCarthy N, Lipper L, Branca G: **Climate-smart agriculture: smallholder adoption and implications for climate change adaptation and mitigation**. *Mitigation of Climate Change in Agriculture Working Paper, 3*. Rome: MICCA Programme, FAO; 2011.