Policy and effective action for soil security: a need for reframing the soil story

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Abstract. Soil science is a vital scientific discipline producing cutting-edge research in its various sub-disciplines. Its role in studying major environmental issues, often defined as food security, water and energy availability, climate change and biodiversity loss, is, however, less obvious to stakeholders, policy makers and the public at large. It deserves better. Reframing the soil story by taking a pro-active interdisciplinary approach in demonstrating the role of soils when studying these issues is advocated in the context of the ten Sustainable Development Goals. Soil change matters not only in a negative way when referring to erosion and degradation but also, and particularly, to soil improvement. But only successfully completed programs in practice will be convincing and that’s why an active role of soil researchers and soil scientists, acting as knowledge brokers, is advocated in transdisciplinary programs. This includes more emphasis on preparation and implementation than is allowed in current programs. A case study is presented and a narrative is used to link the five major environmental issues in a logical sequence, showing their interdependence. Current soil research and education programs should reflect demands made by inter- and transdisciplinary approaches and need a new, fresh approach.

1. Introduction

The title of this conference is well chosen. Mankind is facing a number of major environmental challenges in the coming decades as the world population is likely to exceed 9 billion. Strategic reports on the state of the environment usually list food security, freshwater and energy shortages, climate change and biodiversity loss as key environmental issues. The preservation of soils, as such, is usually not listed as a key issue but the way the soil resource is changing as a result of human (mis)management certainly is such a key issue, because it has major effects on each of the five recognized environmental issues mentioned above. Perhaps soil science has been too much inward looking, paying inadequate attention to documenting these major effects. Also, when scanning soil science literature, emphasis tends to be on erosion, degradation and pollution of soils, representing soil change in the wrong direction. But soil research has also been quite successful in developing soil conservation and soil improvement techniques that can turn around degradation processes by applying innovative soil management. Even though much knowledge and expertise is available, soil degradation in various forms still proceeds at an alarming scale. The question is, ‘How to raise more awareness and achieve soil change in a positive direction?’ The objective of this paper is to discuss this issue by analysing: (i) the way in which various stakeholders, policy makers and citizens-at-large experience environmental issues and concerns; (ii) the role soil science plays in framing these issues; (iii) ways to effectively participate in inter- and transdisciplinary environmental research programs, and (iv) a case study where an attempt was made to apply some of the ideas being propagated here.
Environmental awareness has increased considerably during the last 50 years, starting with the landmark book by Rachel Carson: "Silent Spring" in the 1960’s, the Club of Rome in the 1970’s, emphasis on Sustainable Development following the Brundtland report in the 1980’s and the activities of the IPCC, studying climate change, also since the 1980’s. The, at least partly successful, UN Millennium Goals of the 2000’s have now been succeeded by the UN Sustainable Development Goals (SDG’s) and Targets for 2030. They reflect a broad societal context in which to consider environmental issues. When discussing soil change, I would propose we do so in the broad context of the SDG’s. The 17 Goals (as established July 2014) can be summarized as follows (http://sustainabledevelopment.un.org):

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improve nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote wellbeing for all ages
4. Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
5. Achieve gender equality and empower women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure and promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and between countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably managed forests, combat desertification and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Each goal is specified by three specific targets, that are not mentioned here. It is easy to be cynical about what can be seen as unrealistic, wide ranging “shopping lists”. Still, they provide a context and specific targets and this is particularly valuable, it would seem, for a relatively small profession as soil science that appears to suffer from a lack of recognition in terms of their role in studying the major environmental problems of the immediate future. Earlier, in the introduction of this paper, key environmental issues that are being recognized in international strategic documents were mentioned. They all come back here, be it in an attractive broad socio-economic context. Food security is key in goals 2 and 12, while of obvious importance for other goals. Water is mentioned in goal 6, climate in goal 13, biodiversity on goal 15 and energy in goal 7.

In summary, the suggestion is to frame our activities in the context of the SDG’s which offer a development context for the world up to 2030. This avoids looking back feeling sorry for ourselves as not being recognized, but putting emphasis on what can and must be done in future. The potential for soil science is immense.
3. Framing soil science in the SDG context

Earlier, Bouma and McBratney [1] and Bouma [2] have emphasized the need to more clearly demonstrate the important role that soils can play to ensure food security and freshwater availability and to combat climate change, energy shortages and biodiversity loss. This is not a difficult challenge: no soils, no crops. Soils are very effective in purifying percolating wastewater thereby protecting aquifers. Next to the oceans, soils contain more Carbon (C) than all the vegetation of the world combined and increasing soil-C is a major route for climate change mitigation. Biofuels grow on soils and improved agricultural practices, avoiding losses of agrochemicals to air and water, are crucial for biodiversity. Rather than laying emphasis on the importance of soils as such, it helps to emphasize the importance of soils for crop production, water purification, climate mitigation and biodiversity preservation. But only talking about this or presenting conceptual and theoretical papers is not going to carry the day. Only specific examples out there in the field that demonstrate successful efforts will be convincing. We need more of those or, better, we should more effectively communicate the many successful narratives that are already there.

The SDG’s, as mentioned above, add an additional socio-economic dimension to restricted environmental discussions and it would be wise to keep the SDG’s in mind when reporting soil studies. For example, female farmers are dominant in many developing countries and agricultural development will therefore be favourable for gender equality (goal 5). When considering the SDG’s, the various roles played by agriculture are quite prominent. Agriculture is crucial to end hunger and extreme poverty, it strongly affects the planetary boundaries of Rockstrom et al [3], population health, climate change, ecosystem services and governance, the latter if only by ownership issues related to land. This discussion is important for soil science as some soil scientists feel that the profession has been too closely related to agriculture in the past and advocate detachment from agriculture and a closer association with the geosciences. This can be done, but when striving for an increased societal profile for the profession by reframing soils, a link with the SDG’s would be wise and that implies, as discussed, the need for a remaining focus on agriculture.

Finally, Bouma [2] pointed out that the five key environmental issues, discussed above, should not be seen in isolation: improving food production (the first issue among equals) may have positive effects on the other four issues and he advocates development of narratives in which all the issues are linked in a logical manner.

4. How to reach out to other disciplines and with stakeholders?

4.1. Interdisciplinarity

Too many papers and strategic documents contain abstract pleas for inter- and transdisciplinarity, the first term relating to work with other disciplines and the second to interaction with various stakeholders and policy makers. Of course, the SDG goals cannot be reached with disciplinary research alone but only talking about the issue of interdisciplinarity is not enough and we should face up to what this really means. It helps to realize that the hydrological, climatological, agricultural and ecological research communities are tightly organized, sometimes resembling closed shops, just like soil science. They, like us, have their own journals, meetings and research programs. Funds are scarce everywhere and colleagues from adjacent disciplines are only being invited as members of interdisciplinary research teams if they can make crucial contributions. The challenge, therefore, is to produce such contributions. How to do that? In order to make predictions of future conditions, the use of simulation models is essential in all disciplines dealing with major environmental issues. Such models are gross simplifications of reality and simplifying input of adjacent disciplines is easier accomplished than simplifying your own input. Soil scientists are often not members of the interdisciplinary teams and are therefore easy victims of simplification. The approach to take by soil scientists needs more discussion but should go beyond expressing an abstract and conceptual need for interdisciplinarity. I would suggest (see also [4] and [5]) to run their models with and without good soil data and compare the results. For example, many current hydrological basin-models do not
contain soil data or use it only in an elementary form. (e.g. Droogers and Bouma, 2014). The hypothesis would be that using up-to-date soil data produces better results. But the verdict is still out as there appear to be no studies so far taking this approach. And important: use their models and not your own! Models are a symbol of scientific virility and recognizing this will be helpful in communicating with colleagues in other disciplines.

4.2. Transdisciplinarity
Working with stakeholders, citizen groups, NGO’s and policy makers is complicated (see also [6]). The old paradigm of scientists studying self-defined problems and producing “solutions” that are passed on to grateful citizens to be applied in practice is not realistic anymore, nor has it ever been. The relation between science and society is changing dramatically in the 21st century if only because of modern information technology. Lessons were learned in a major research program in the Netherlands on Sustainable Agriculture, as reported by Bouma et al [7]. The SDG’s and their specific targets present “wicked” problems for which no single, “magic” solutions exist. Complicated and cumbersome compromises have to be found balancing economic, social and economic considerations.

Two major conclusions were reached in the Dutch study:
(i) before starting any project, more time should be spent in defining stakeholders involved and their opinions, interests and hidden motives. Such motives are often only expressed over a beer rather than in formal settings. As is, researchers often spend most of their time on formulating project proposals with minor, superficial contacts with stakeholders, followed by a quick start once the project has been funded and preparations for the next project while the former one is still in progress;
(ii) what really counts in the end are specific results. Just delivering reports and writing papers is not enough. The important role of “knowledge brokers” was identified in trying to realize implementation of plans. They are, ideally, members of the scientific team and have a high social intelligence being able to make the right injections of knowledge at the right time and place and manner to move things along. As is, we often ignore this implementation phase and move on to the next project. As many, if not all, environmental issues are land related, soil scientists would appear to be in an excellent position to act as “knowledge brokers”, the more so since soil surveys in the early phase of the profession involved extensive contacts with land users.

5. A case study reflecting an inter- and transdisciplinary struggle
In the early 1990’s dairy farmers in the Northern Frisian Woodlands (NFW) in the Netherlands challenged environmental legislation on ammonia emission from manure spread at the soil surface, that was believed to have adverse effects on nature quality in adjacent nature areas. The NFW area was designated as a “national landscape” because of its small scale character with hedgerows separating relatively small, elongated fields. To reduce emissions, farmers were required to inject liquid manure in the soil and they did not like that because they expected damage to soil structure and loss of control because the heavy machinery to be used was operated by independent contractors.

Besides, operating large machines on small fields offered operational problems. They proposed an alternative by feeding their cows a low-protein diet resulting in manure (“new” manure) with less ammonia, as had been proved to be feasible elsewhere [8]. This way they could realize comparable ammonia emissions as found when injecting manure. However, this was against the law and several farmers received fines of thousands of euros when they refused to inject their manure. This resulted in a decade-long struggle with legislators and researchers as reported by Bouma et al [4] as case study no.1.

In the late nineties the government allowed experimentation for a limited number of farmers but results were inconclusive, partly because of disagreements among researchers. As time went by, the farmers increasingly broadened the scope of their activities, embracing a “cradle-to-cradle” approach
that was studied in 2010 with Life Cycle Analysis (LCA) [9]. The “cradle-to-cradle” approach included use of less chemical fertilizers and external inputs and an increased application of animal manure, produced on-farm.

A dramatic point was reached in July 2013 when the government decided that experiments would be terminated and that farmers had to abide by the existing law. Following an intensive political campaign, all parties (!) in the Dutch Parliament approved a motion asking the government to extend the experimental period for another five years for a large number of farmers, allowing them to apply their “new” manure at the surface. This may result in a de facto approval of the cradle-to-cradle approach, including surface application of “new” manure, and illustrates both the importance of this issue on national level and the impact of successful lobbying.

The LCA study compared seven cradle-to-cradle farms (C) with seven comparable farms using more traditional procedures (T). In summary, both populations had very large standard deviations but results showed that:

(i) C had 20% higher soil organic matter contents (186 versus 156 tons/ha) partly because meadows were not plowed and reseeded every five years as were most of the T meadows. The difference was statistically significant;

(ii) C used 15% less energy than T (4.9 MJ/kg milk versus 4.3 MJ/kg) because they applied their manure themselves rather than engage contractors and they used less chemical fertilizer. The difference was statistically significant;

(iii) Values for global warming-, acidification- and eutrophication potential were lower for C but not significantly so. Also application rates for chemical fertilizers were lower for C (128 kg N/ha versus 146 kg N/ha) but this difference was not statistically significant either. Average measured nitrate contents of groundwater were 12 mg/l for (C) and 22 mg/l for (T). No significant difference and in any case both below the EU threshold of 50 mg/l, and

(iv) Average income for C farms was 40% higher than for (T) but standard deviations were very high and the difference was not significant. C farmers received subsidies for maintaining their hedgerows, which contributed towards their higher income.

The NFW study allows a narrative, as mentioned above, in terms of an efficient production system of milk providing a higher income to farmers, partly because of lower production costs, while water quality is improved, and the soil organic matter content increases, providing a contribution to climate mitigation. Energy use was significantly lower and lower emission of nitrogen compounds was favourable for biodiversity in surrounding nature areas. In addition, hedgerows, that were maintained in the (C) system, contributed significantly to biodiversity.

In summary, all major environmental issues, as mentioned in the introduction, are being served by the (C) system under the overall banner of food production and this conclusion can be extended to the SDG’s by recognizing that implicitly contributions are made to stay within the planetary boundaries of Rockstrom et al [3] (Goals 2,6,7,13, 14,15), that rural prosperity has increased (goal 8), while serving goals 7 and 13 in terms of climate and energy and goal 15 in terms of biodiversity, water and soil. Goal 17 is intriguing. The NFW study showed government to be highly risk averse and top-down, unable to respond to bottom-up initiatives that, if embraced in a timely manner, would have supported government objectives. Also, concepts of environmental indicators, thresholds and proxies were poorly defined, requiring more transparency (e.g. [10]).

Indicators for groundwater quality are clear: nitrate concentrations are defined by a threshold of 50 mg/l. However, as little monitoring data were available around 1990, a proxy of 170 kg N/ha was defined. This was fine at the time, but now many monitoring points provide lots of data on groundwater quality, if only because of the availability of modern sensors, and there is good reason to move away from indirect proxies and focus on the threshold itself. The ammonia story is more complicated. The indicator is defacto deposition of N in nature areas, which is hardly measured up to the present time and is calculated with models. The Government has only defined a national emission threshold of 128 kton ammonia, but this not regionally specified. The proxy of manure injection is intended to reduce ammonia emission from the field and measurements show that this can be
achieved. But how about deposition, the real threshold? The research community was divided and provided poor advice to regulatory agencies. In retrospect, more transparency and clarity of objectives could have resulted in better governance. Farmers are willing to follow environmental rules because a good environmental quality is a key element of their operations. But when rules are unclear and cannot be explained, their resistance is justified and should be taken seriously.

But overall, “soil change matters” and change was clearly positive here because soil quality has improved as the higher organic matter content leads to a higher moisture supply capacity, better filtering capacity and higher soil biodiversity.

6. Lessons learned

Soil science is a vital scientific discipline producing cutting-edge research in its various sub-disciplines. Its role in studying major environmental issues, often defined as food security, water and energy availability, climate change and biodiversity loss, appears to be, however, less obvious to stakeholders, policy makers and the public at large. This should be improved because the societal relevance of soil science is not as high as it could and should be. The following suggestions are made that can contribute to the necessary reframing (see also [1], [2]):

(i) Taking a pro-active interdisciplinary approach in demonstrating the role of soils when studying the five major environmental issues, as advocated in the context of Sustainable Development Goals.

(ii) Taking an active role in transdisciplinary efforts by developing a role as knowledge broker. Spend more time in preparing research programs by seriously involving stakeholders and stay involved in the implementation phase.

(iii) Reconnecting the knowledge chain, linking tacit knowledge and field experience to basic soil research in both directions. This link was well developed in the past when soil surveyors were in close contact with researchers but appears to be broken now. A transparent knowledge chain can also be effective in improving environmental regulations by explaining relations between indicators, thresholds and proxies, as discussed in the case study.

(iv) Judging scientific quality not only by current quality indicators primarily based on publications in international scientific journals but also by its societal relevance, reflecting current discussions about the relation between science and society in the 21st century. (www.scienceintransition.nl)

(v) Reflecting requirements of inter- and transdisciplinarity in soil education and - communication.

(vi) Showing that Soil Change Matters by not only emphasizing negative changes, following erosion and degradation, but also by showing successful applications of innovative management leading to positive changes in soil quality. Emphasize the role of and the impact on real-life people when describing case studies in terms of a narrative. Only real examples in the field, such as the NFW study, are convincing. There are many more to be told. Shout them from the mountain top!

A final comment on the question whether or not it is wise to keep emphasizing the role of soils while people at large, policy makers and entrepreneurs do not recognize our subtle differences between the terms soil, land or, it must be said, “dirt”. The word “land” touches a nerve with many people: “This Is My Land!” We talk about “land evaluation” when defining land use potentials, not: “soil evaluation”. (e.g. [11]). Still, land evaluation is a broad concept involving economic and social aspects as well as the impact of many other scientific disciplines than soil. A continued focus on soil is attractive and needed to establish and maintain our role in the overall studies on land evaluation. But we should always keep the broader picture in the back of our minds when facing our daily grinds.

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