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SOILS in SEEA

Outcome of a literature review and initial analysis

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SOILS in SEEA – Outcome of a literature review and initial analysis

1. Soils are an integral element of both agricultural land and (semi-)natural ecosystems. Together with other components, soils sustain the system's capacity to produce; i.e. a fertile soils is useless if it is not combined with a certain amount of water to support plant growth. Hence, it is difficult to attribute ecosystem or agricultural outputs to soils only, these outputs are always the result of a combination of ecosystem components (soil, water), processes (e.g. denitrification, nitrogen fixation, etc.) and usually human management.

2. Although it is impossible to attribute ecosystem output to one specific component, there is of course a relation between degradation of one specific ecosystem component and the ecosystem's or agricultural output. For instance, many studies record the impact of soil degradation on agricultural yields. However, given the interconnectedness of the ecosystem, soil degradation cannot be seen in isolation from other ecosystem components. In particular, soil degradation will often affect the water holding capacity and/or infiltration rate of the soil, influencing water availability to plants. Hence, if the relation between soil degradation and plant growth (or crop yields) is examined, it usually involves a regression between one or a few critical indicators for soilquality and yields. These indicators reflect not only the physical composition of the soil, but indirectly also related aspects such as soil biodiversity (e.g. density of soil fauna) and water holding capacity.

3. The role of soils in the supply of ecosystem services is depicted in Figure 1 below. Figure 1 shows that soils are an integral part of farm land and other ecosystems, and that ecosystem services are generated by the overall entity (i.e. the farm land or the ecosystem). Figure 1 also shows that some of the services accrue to the farmer or land owner (e.g. wood harvest), others to society as a whole (e.g. carbon sequestration). Finally, Figure 1 shows that part of the integral elements of the farm land or ecosystem are on-site and controlled by the land manager (e.g. the soils) and other elements are 'off-site' and may not be controlled by the farmer or land owner (e.g. the availability of irrigation water).

4. Note that Figure 1 only shows two types of land holdings, 'farm land' and a 'semi-natural ecosystem' (e.g. a secondary forest). Very few fully natural ecosystems remain on the planet. However there are many intermediate forms, with an intermediate degree of human control over the land use system, such as extensive grazing land (e.g. the Sahel).

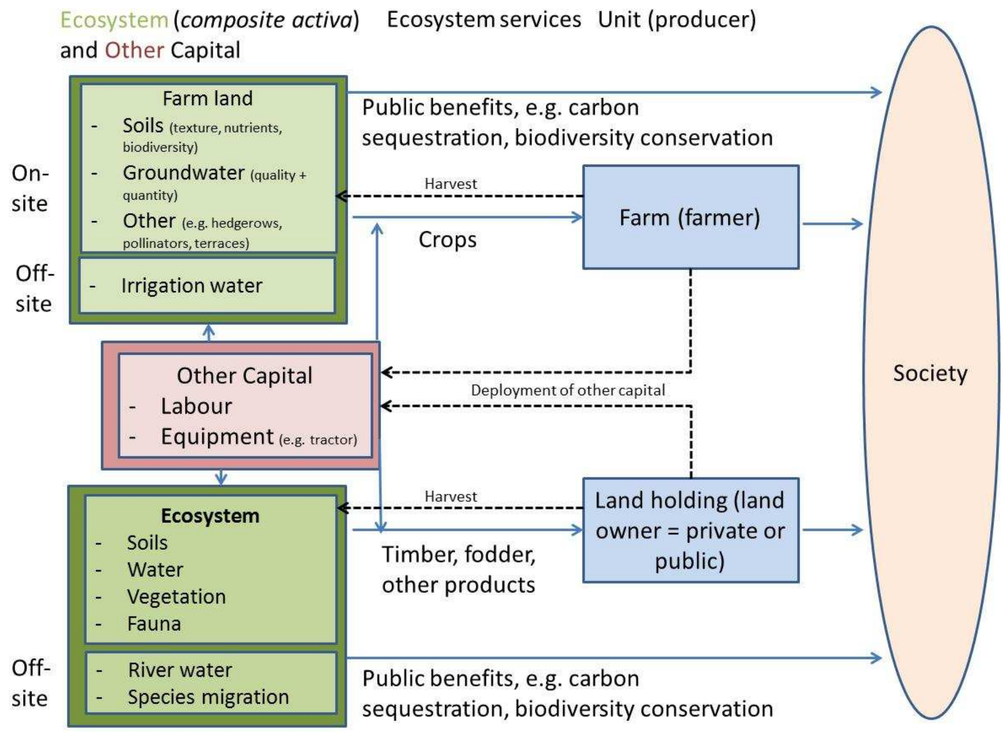

Figure 1. Soils as an element of ecosystem capital in agricultural land and semi-natural ecosystems. Note that the land owner deploys capital both to (i) transform the ecosystem, usually in order to enhance the productive capacity of the ecosystem (e.g. through fertilisation of farm land or pruning of trees in a forest); and (ii) to extract provisioning services/products (e.g. to log a forest or harvest a crop). The land owner generally manages the plot of agricultural land or a plot of a semi-natural ecosystem in order to maximise the supply of certain benefits (e.g. wood, timber, a cultural service) and unintentionally also produces positive (carbon sequestration) and/or negative (ammonia emissions from cropland) externalities.

5. In agricultural land, soil management is key to maintaining the productive capacity of the system. Soil quality is a key indicator for the composition and functioning of the ecosystem, and (almost) every farmer will pay close attention to soil fertility.

6. In natural ecosystems, soils are also an important component of the ecosystem. In some ecosystems, soil quality is, as in agricultural land, a key indicator for the functioning of the ecosystem (e.g. soil nutrient depletion in tropical grazing lands). However, in other semi-natural ecosystems, soil quality is not the most important indicator for ecosystem functioning, in the sense that isnot the clearest or most meaningful expression of the state of the ecosystem (in addition to being relatively difficult to measure compared to other indicators for the functioning of semi-natural ecosystems). For instance, in some types of tropical forest, degradation is strongly related to logging or patterns of shifting cultivation. Even though logging and shifting cultivation affect the soil, the status of the ecosystem may be more easily and more directly correlated to the state of the vegetation cover (which in addition can be more easily measured, with remote sensing images rather than soil sampling programs). Finally, some types of degradation such as a loss of fauna due to hunting, or the invasion of an ecosystem by exotics, may hardly be reflected in soil properties at all.

7. The practical implication of the above for SEEA is that it needs to be examined if the use of soil indicators perhaps need to be recommended for agricultural land, but not (in all cases) for semi-natural ecosystems.

8. Agriculture takes place on a wide variety of soil types. Suitable indicators for soil quality vary between these soil types. For instance, soil organic matter is a highly suitable indicator for the overall status of nutrient poor, tropical soils, but not for the status (i.e. for the capacity of the soil to support agriculture) of peat soils.

9. Potential indicators for soil quality to be considered includesoil organic matter content, total plant available phosphor content, Cation Exchange Capacity (CEC) - which reflects both texture (clay content) and soil organic matter content, and pH (both acidic and alkaline soils are less suited for agriculture, and human management may impact pH in case of inappropriate soil management. For some soils (e.g. peat), the depth of the water table is a critical indicator for soil functioning. Note that the depth of the water table is also a critical indicator for the functioning of (semi-)natural forests on peatland.

10. Also relevant are indicators that reflect a reduction in the capacity of the soil to sustain certain services, such as heavy metal content or the content of pesticides / pesticide residues, the latter in particular in agricultural soils.

11. The suitability of all indicators strongly depends upon the context. In nutrient poor African soils, soil organic matter (SOM) and plant available Pare critical indicators. A decline in SOM often directly leads to a decline in output. However in soils with a very high supply of manure and fertilizers, as in most of the OECD agricultural lands, SOM is less relevant as an indicator for degradation or the capacity of the system to support agricultural production.

12. <u>On the OECD Soil Nutrient Balances</u>. The OECD has developed an elaborate system to report soil indicators including nutrient balances at the national and in some cases at the sub national (NUTS3 in the EU) scale. The OECD reports for all member states among others agricultural production, agricultural land use, phosphorus (P) balances, nitrogen (N) balances, greenhouse gas emissions, and pesticide use. Some countries additionally report specific elements relevant for it's context, such as soil carbon stocks, the presence of traditional farm elements (hedgerows, a.o.), water use, etc.

13. The N and P balances reported by OECD are constructed principally at the national level. They include quantities of N and P inputs (manure and inorganic fertiliser) and outputs (crops, pasture). The various OECD publications reviewed (e.g. Environmental Performance of Agriculture in OECD countries since 1990, OECD 2008) present only national level balances, with some examples of sub-national data (however for some countries, in particular in the EU, farmers need to register and report the annual nutrient balances of their farms and more detailed information should be available at the national / EU level)

14. The N and P balances indicate the amounts N or P added or extracted from the soil at the national level. They are a good indicator of the amounts of nutrients ending up in the environment (i.e. an environmental pressure). They are also an indicator of potential soil nutrient depletion. At the national level, however, OECD countries tend to have both an N and a P surplus, leading to eutrophication when the nutrients are washed out to waterways.

15. In addition, OECD reports on erosion risks of countries, reporting land falling in different categories of erosion risk, for water and wind erosion.

16. The OECD reporting system includes several indicators highly relevant to soil quality (i.e. reflecting the capacity of the soil to sustain production), in addition to several key indicators reflecting environmental pressure from agricultural soil management in OECD countries. For many non-OECD countries, different sets of indicators would need to be defined. In addition, a key issue is that national or sub-national level deficits or surpluses not point to local changes in soil quality (in an extreme case, a major soil nutrient depletion in one part of a country could be

masked by a major increase in soil nutrients – but not necessarily soil quality - in another part of the country). Hence, further conceptual work is needed to develop a system for recording soils in SEEA.

17. <u>The Dutch / RIVM soil ecosystem services approach.</u>An approach that offers a slight conceptual modification that should be considered in our discussions has been developed by soil scientists from RIVM and Wageningen University (RIVM, 2008: Soil Ecosystem profiling in the Netherlands with ten references for biological soil quality). Their concept is slightly different from the more holistic view of the Millennium Ecosystem Assessment. The RIVM study defines soil as an ecosystem in itself comprising an abiotic platform (the soil and water contained in the soil) and a biotic component (the various organisms living in the soil). This approach also involves a slightly different definition of ecosystem services, with which the authors mean the contributions that the soil makes to support agricultural activities (on farm land) and to support plant growth in forests (the first part being much more elaborately worked out in their report than the part relating to forests). Examples of soil ecosystem services are: disease and pest control, water retention, nutrient retention, soil structure, turn over organic matter, soil biodiversity, and climate functions.Soil structure, for instance, is not an ecosystem service in the thinking of the Millennium Assessment. These 'soil ecosystem services' have been monitored on 380 locations in the NLs since the mid 1990s, all locations being sampled once each 6 to 7 years. This approach allows a very detailed quantification of soil properties, but there has not yet been an analysis of the link between these properties ('soil ecosystem services') and agricultural production and the supply of other ecosystem services in the sense of the MA and CICES.

18. This RIVM / Wageningen soil scientist approach lays out some of the consequences for the EEA when the soil itself is defined as an ecosystem rather than the complex of the soil, water, the above and below ground living organisms and the human management. An advantage of seeing the soil as an ecosystem in itself is that it is possible to take a very compartmental approach to analysing natural / ecosystem capital, and that each compartment can be analysed with specific, mono-disciplinary indicators. A challenge is that the link between the status of the compartment (the soil, or the groundwater reservoir) and the economic output of the ecosystem is very hard to establish because this output always depends upon a combination of components (soil, water, living organisms) and their management. In addition, monitoring a set of different compartments instead of one ecosystem comprising different compartments is much more data intensive. The RIVM study monitored 10 ecosystem properties / 'soil ecosystem services' – and found large spatial and intertemporalvariaton.