SOIL AGRODIVERSITY – AN ASPECT OF FARMERS' MANAGEMENT OF BIOLOGICAL DIVERSITY

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Biological diversity in areas of land use (called 'agrodiversity' in the *People, Land Management and Environmental Change – PLEC* - project) is not simply a function of the diversity of species and varieties of biota. Naturally, it does concern standard ecological biodiversity aspects (often termed 'agro-biodiversity' or 'agricultural biodiversity')[1]. Usually it is used to tell the tale of how modern agricultural systems are tending to reduce biodiversity to the detriment of habitats, landscapes, ecosystem functions and the goals of the *Convention on Biological Diversity*. However, agrodiversity also contains a 'good news' story that many small-holder farmers world-wide have been managing their land use to the better conservation of biological diversity, to the improvement of their biophysical environment and to the benefit of their livelihoods.

Centred on farmers' management, this view of biodiversity as a suite of diverse activities, temporally and spatially, using diverse interactions with the biophysical environment should be a cornerstone in global attempts to conserve biodiversity. The GEF-funded *PLEC* project attempts to capture these many and varied management activities and the interactions between rural livelihoods and biodiversity. Since much of this management and associated natural biodiversity is based in and on the soil, it makes sense to focus substantial attention on what may be called 'soil agrodiversity'.

Soil agrodiversity is a subset of the more general term 'agrodiversity', the conceptual framework for which was published by Brookfield and Stocking (1999), that focuses on human-soil and soil-plant interactions. It is a state of the soil in a managed agricultural system where ecosystem functions and services have been enhanced through the manipulation of biological and organic resources (Figure 1). Where the resultant status of the soil can be indicated as fertile, productive, high quality, resilient and robust with respect to soils that have not been so manipulated, a soil could be considered as agrodiverse. Direct indicators of soil agrodiversity include the number and variety of bacteria, fungi, protozoa, invertebrate animals and other aspects of below-ground biodiversity. However, of more immediate importance to land users and their systems of management, below-ground biodiversity tracks soil-surface and above-ground biodiversity. Though the community of organisms in the soil are probably more functionally resilient than those above the ground (Giller et al, 1997), indicators of soil agrodiversity are to be found more readily in how the soil, plant residues and related aspects of water, nutrients and sediment are managed. Some of these complicated

[1] The distinctive components of agricultural biodiversity listed by Cromwell et al (2001, p.80-82) are: crop diversity; 'wild' plant biodiversity; below-ground plant biodiversity; microbial biodiversity in agriculture; and arthropod biodiversity in agriculture.

interactions are categorized in Figure 1, along with their potential beneficial effects on biodiversity and people's livelihoods.

The essential features of soil agrodiversity as presented here are reflected in beneficial attributes at three scale levels. First, **site-based** benefits include an increase in *soil resilience* or the ability of the soil to withstand external shocks such as a severe rainstorm causing floods and erosion, or a sudden change of land use such as deforestation. A resilient agrodiverse soil will recover more readily and continue to produce. This has been illustrated with respect to soil erosion and how a naturally resilient soil's capability may be exploited by land users (Stocking, 2000). *Soil quality* and *soil fertility*, both relative expressions of a soil's intrinsic value to society, are capable of manipulation and management. In an agrodiverse management system, the quality is based upon biological processes, such as the natural release of nutrients and the retention of plant-available water by an open soil structure and balanced range of particle-sizes. Therefore, as quality increases, the efficiency of utilisation of inputs usually also increases. As fertility is enhanced, the range and density of plants that can be supported also increases, with corresponding benefits to both biodiversity and livelihoods. Secondly, there are **management and organisational** benefits. An agrodiverse soil is easier to till, should require less weeding and be less costly to maintain in production. In terms of farming strategy, an agrodiverse soil holds open more cropping possibilities and many opportunities for diversified (and hence risk-minimised) land use. Thirdly, there are **landscape and social** benefits. An agrodiverse landscape enables local economies to diversify, allow farmers to trade-off activities at one site in favour of another in response to external forces such as market prices, and support whole communities in the further diversification of rural livelihoods. One of the emerging issues in rural development is the trend to a U-curve of diversification, where the poor join in non-farm activity as a survival or coping strategy, and the rich as an accumulation strategy (Maxwell et al, 2001). Since the IFAD Rural Poverty Report 2001 claims that three-quarters of the 1.2 billion people living below US$1 per day are rural, the role of agrodiversity in providing socio-economic opportunities to diversify livelihoods cannot be under-estimated. Additionally, agrodiverse landscapes built on agrodiverse soils have a far higher amenity value, attracting tourism, visits to the countryside and better policy responses from urban elites. These benefits, of course, are not solely based upon the soil, but they are literally and metaphorically rooted in systems of land use that manage the human-soil-plant interactions in such a way as to encourage biophysical diversity.

Examples of soil agrodiversity are drawn from a number of *PLEC* and non-*PLEC* sites in East Africa. In the Matengo Highlands of SW Tanzania, the land preparation technique known as *ngoro* pits is not only an ideal protection against soil degradation on these steep slopes, but also opens the opportunity for a far wider array of plants to be grown. In the Arameru District of northern Tanzania, agro-pastoralists have developed sustainable land use systems across a landscape, varying from humid high-mountain to semi-arid, that are based on maintaining high levels of soil organic matter but in radically different ways according to biophysical conditions. Finally, in Mbarara District of south-central Uganda, farmers have exploited the enormous market opportunities for banana varietals, by developing deep organic-rich soils through mulching and water-harvesting. This last case is one where in-situ conservation of rare varietals of an important food crop has occurred despite large increases in population and the influence of urban markets. Without an agrodiverse soil, including rich below-ground biodiversity, the heavy use of biological components on the soil surface and complex soil management techniques, rural poverty would be far greater.

References

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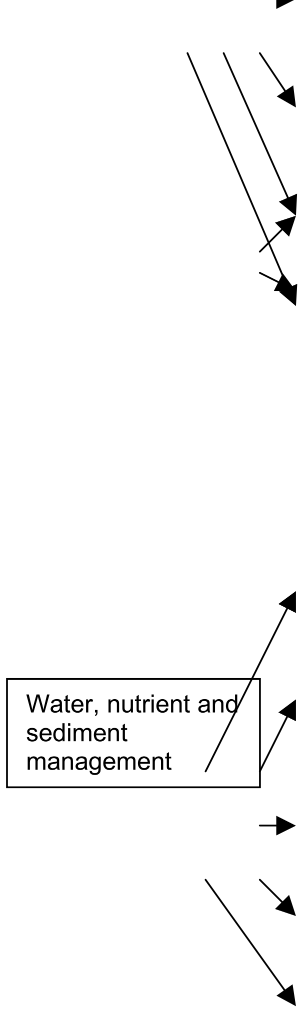
Broad Group of Soil Activities

Soil preparation

Soil organic matter management

Plant management effects on soil

Soil-based activity	**Effect on biodiversity**	**Implications for livelihoods**
Soil tillage – conventional ploughing	Generally negative in suppressing weeds, humifying soil organic matter, depleting beneficial soil structure and creating soil surface more likely to erode	Tillage requires capital outlay in resources and substantial labour.
Soil surface formation – micro-relief. E.g. ridging practices	Positive – different plants using different ecological niches	Requires labour, but brings benefit through better water infiltration and plant cover. Indigenous systems, such as *zaï* pits, have supported livelihoods for centuries in difficult environments
Soil surface plant residues – including conservation tillage	Positive – provides for richer below-ground biodiversity, less erodible soil and conducive micro-climates.	Helps to suppress some weeds and reduce labour. In mechanised systems, additional capital resources necessary as well as herbicides.
Incorporation of residues	Ambivalent – increases humification of organic matter, but decreases soil erodibility. Soil biota may respond positively in the short-term.	Requires equipment. Residues no longer available for domestic animals – a negative impact for many tropical smallholder farmers.
Green manuring and biomass crops	Positive – can greatly increase soil organic matter and water-holding capacity with benefits for soil quality and resilience.	Takes land out of direct production – but minimised if green manure grown on residual soil water out-of-season. Needs expenditure in seeds and equipment.
Weed mulching and weed fallow	Positive – increases organic matter, reduces soil disturbance and allows soil recuperation.	Takes land out of production – but low cost fallowing, with some beneficial weed species.
No-till and	As for 'Soil surface	As for 'Soil surface plant



direct drilling	plant residues'	residues'. Direct drilling equipment expensive.
Contour planting	Positive – retains water and sediment, reduces erosion rate.	Low cost plant management option with large pay-back in soil quality and future yields.
Sediment traps – structures or live barriers	Ambivalent – creates new fields at expense of loss of soil from upper slopes. But net economic benefit positive and prevents further problems downstream	Where used to trap sediment, large increase in livelihood support giving production where none had been possible before. Investment of labour and capital in building and maintenance.
Fertilisation – organic or inorganic	Positive – increases potential biomass and plant diversity. Some chemical toxicity side-effects possible with inorganics.	Labour and/or cost of inputs. Nutrient additions of inorganics have immediate effect but productivity gains may not last.
Irrigation	Positive – increases potential plant production and lengthens growing season.	Expensive to install and maintain. Many associated problems of maintenance and environmental impacts such as salinisation.
Soil and water conservation structures	Positive – increases productive potential by retaining soil and water on-site.	Expensive to install and maintain.

Figure 1. Soil agrodiversity – components, implications and effects