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Managing Africa's Soils No. 23

Reversing the degradation of arable land in the Ethiopian Highlands

Tilahun Amede, Takele Belachew and Endrias Geta

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AHI

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About the authors

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About NUTNET

NUTNET is a network that aims to improve the management of soil fertility in Africa. It is a partnership of fifteen organisations from six African and two European countries: INERA, Burkina Faso; SOS Sahel, Ethiopia; KARI, KIOF & ETC East Africa, Kenya; IER, Mali; Environment Alert & University of Makerere, Uganda; IES, Zimbabwe; IIED & IDS, United Kingdom; and AB/DLO, LEI/DLO, SC/DLO, ETC & KIT, The Netherlands. NUTNET is funded by DGIS, the Ministry of Foreign Affairs in The Netherlands.

About *Enhancing soil fertility in Africa: from field to policy-maker*

This project builds on the work done by the NUTNET network, which has been extended to include the Swedish University of Agricultural Sciences (SLU), the Universidad Complutense de Madrid (UCM) and the National Agricultural Research Foundation (NAGREF) from Greece. It is funded by the International Co-operation for Development (INCO) programme of the European Union, which links ongoing research projects on soil fertility management in sub-Saharan Africa, focusing on the implications of diverse social, economic and environmental settings, and the differing perceptions held by stakeholders of research and policy design.

Acknowledgments

This research was jointly conducted by farmers from Gununo and a multidisciplinary team of scientists from the Areka Research Centre, the Areka Bureau of Agriculture, the Awassa Research Centre, the Awassa College of Agriculture, the Melkassa Research Centre, CIAT and ILRI. We wish to thank them all for their constructive collaboration. We would also like to thank Dr. Ann Stroud and Dr. Roger Kirkby for the continual support they provided in the learning and research process, and IIED for editing this paper. Funding from the INCO project enabled us to publish our findings.

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Summary

Degraded soils are a major constraint to agricultural production and food security in the southern Ethiopian Highlands. As their yields and incomes decline, poor farmers have fewer resources to invest in fertilisers or soil conservation measures, while pressure from the growing population forces them to cultivate marginal lands, and discontinue fallow and the use of crop residues to maintain soil fertility. Soil fertility is declining most rapidly in the outer fields, as crop residues from these areas are used on the homestead gardens where enset and coffee crops are grown, which also receive the most manure and organic waste. Farmers need to adapt their soil fertility management strategies to the considerable spatial and temporal variations in soil degradation, focussing on restoring and maintaining the fertility of outfields and degraded land on steep slopes.

The African Highlands Initiative (AHI) and Ethiopian Agricultural Research Organisation responded to this situation by setting up a participatory research programme on natural resource management. The overall objective of the programme was to increase the capacity for independent innovation within farming communities, while working with farmers to develop appropriate technologies to combat soil degradation. Farmers spent three years testing various methods of restoring soil fertility, introducing legume cover crops into rotation systems, installing measures to control soil erosion, and practising minimum tillage and more efficient ways of managing crop residues. The results of the research showed that adoption of these technologies depended on factors such as farm size, the availability of labour and soil condition.

Research conducted during the programme identified five socio-economic strata within local communities, each with clearly different opportunities and needs. Any attempt to address agricultural problems should take account of this diversity, as blanket recommendations or technology packages are unlikely to provide effective solutions to the range of problems faced by farmers. Their interests will best be served by using a participatory approach to develop technologies that address the needs and specificities of each group, and by ensuring that farmers are fully involved in all stages of the process, from research and implementation to monitoring and evaluation.

The AHI team found the participatory approach to research a very positive experience, which helped them identify problems and develop technologies that were specifically tailored to local conditions. The main achievements of the programme were to increase the capacity of farmers to solve their problems through experimentation and encourage various organisations to work together and learn from each other. The next step is to move from discipline-based research towards research and development in integrated natural resource management at watershed level.

Résumé

La dégradation des sols est un obstacle à la production agricole et à la sécurité alimentaire dans les Highlands d'Ethiopie. A mesure que leurs rendements et leurs revenus diminuent, les agriculteurs pauvres ont de moins en moins de ressources à investir dans les engrais et les mesures de conservation des sols, tandis que la pression d'une population en expansion les contraint à cultiver des terres peu fertiles, à abandonner les jachères et à arrêter d'utiliser les résidus agricoles qui maintiendraient la fertilité des sols. Celle-ci décline le plus rapidement dans les champs éloignés car les résidus agricoles provenant de ces champs sont utilisés dans les jardins près des maisons qui reçoivent également l'essentiel du fumier et autres déchets organiques parce qu'ils produisent des bananes d'Abyssinie et du café. Il y a donc des variations considérables de la façon dont les terres arables sont touchées par la dégradation des sols et les agriculteurs doivent adapter leurs stratégies en conséquence et en privilégiant la restauration et le maintien de la fertilité des champs éloignés et des terrains en pente dégradés.

En réponse, l'Initiative AHI (African Highlands Initiative) et l'Organisation Ethiopienne de Recherche agricole (Ethiopian Agricultural Research Organisation), ont engagé des recherches avec des agriculteurs d'Areka sur la gestion des ressources naturelles pour développer des technologies compatibles avec le système de production pour combattre la dégradation des sols et accroître la capacité des agriculteurs et de leur communauté à innover d'eux-mêmes. Diverses technologies permettant de restaurer la fertilité des sols ont été essayées par les agriculteurs au cours des trois dernières années, y compris une meilleure gestion des résidus agricoles, l'introduction de légumes intercalés dans la rotation des cultures, des mesures de contrôle de l'érosion des sols et un minimum de labourage. L'adoption de ces technologies dépendaient de facteurs tels que la taille de l'exploitation, la réserve de main-d'œuvre et l'état de dégradation des sols.

Du fait que nous ayons identifié cinq strates socioéconomiques dans la région, chacune avec des possibilités et des besoins clairement différents, les recommandations et les technologies toutes faites ont peu de chance d'apporter des solutions efficaces aux problèmes que rencontrent les agriculteurs locaux. Leurs intérêts seront mieux pris en compte par une approche participative au développement de technologies qui correspondent aux besoins et spécificités de chaque groupe et qui garantissent que les agriculteurs soient totalement impliqués à toutes les étapes du processus, depuis la recherche et mise en oeuvre, jusqu'au suivi et à l'évaluation. Notre principale réalisation aura été d'accroître la capacité des agriculteurs à résoudre leurs problèmes par l'expérimentation, et à encourager diverses organisations à travailler ensemble et à apprendre les unes les autres. Employer une approche participative à la recherche a été une expérience très positive pour AHI. Elle a aidé l'équipe à identifier des problèmes et à développer des technologies mieux adaptées aux conditions locales. La prochaine étape consiste à passer d'une recherche axée sur une discipline, à une recherche dans le domaine de la gestion des ressources naturelles des bassins-versants.

1 Introduction

The Ethiopian highlands are affected by deforestation and degraded soils, which have eroded the resource base and aggravated the repeated food shortages caused by drought. Although the Highlands occupy 44% of the total area of the country, 95% of the land under crops is located in this area, which is home to 90% of the total population and 75% of livestock (SCRP, 1996). Declining vegetative cover and increased levels of farming on steep slopes have eroded and depleted soils in the area, so that soil degradation is now a widespread environmental problem. Farmers also have to cope with nutrient mining caused by insufficient application of fertilisers, shorter fallow periods and low levels of soil organic matter.

The research discussed in this paper was conducted in Gununo, in the Bolosso Sore district (Areka) of Wollayta Zone in the Southern Nations, Nationalities and Peoples Region (SNNPR) of Ethiopia. Gununo is situated about 430 km south west of Addis Ababa. Over the last thirty years, governmental and non-governmental institutions have made various attempts to restore the fertility of degraded arable land, with initiatives such as the Wollayta Agricultural Development Unit (WADU), set up in 1971 to provide extension and credit services for farmers in the southern highlands of Wollayta. Operational until 1982, WADU demonstrated, popularised and subsidised packages of mineral fertiliser, improved varieties of seeds, and pesticides. Crop yields doubled as a result of its activities, but when subsidies were phased out in the 1980s and the price of inputs rose, the use of mineral fertilisers and pesticides declined sharply. In 1982, the Swiss supported the launch of the Soil Conservation Research Programme (SCRP), which ran until 1993, developing and disseminating soil and water conservation technologies in Wollayta.

African Highland Initiative

In 1997, an integrated soil fertility management project was launched in Gununo. This was a collaborative venture involving the African Highland Initiative (AHI, see Box 1 below), the Areka research centre, farmers and scientists from the Awassa research centre, the Awassa College of Agriculture, CIAT and the International Livestock Research Institute (ILRI). The aims of the programme were to:

a) Study the factors affecting the adoption and dissemination of available technologies;
b) Test various soil fertility amendments with farmers from different socio-economic strata and identify their criteria for choosing particular options;
c) Develop methodologies and processes that could be useful for soil fertility management outside the research site.

Box 1. The African Highlands Initiative (AHI) and research into natural resource management

The African Highlands Initiative is a collaborative programme aimed at promoting better livelihoods for farmers and sustainable use of the natural resource base in the East African Highlands. Launched in 1995, AHI involves the international agricultural research centres (IARCs) and national agricultural research institutions (NARIs) and operates in eight benchmark sites across Ethiopia, Kenya, Uganda, Tanzania and Madagascar, conducting participatory research with farmers into the integrated management of natural resources. Gununo (Areka) is one of these sites. The aim of the research is to increase the capacity of farmers to innovate independently, to develop system-compatible technologies, to improve partnerships among all stakeholders and to promote the scaling-up of technologies, methodologies and processes.

Research methods

In 1997, a multidisciplinary team of AHI-Areka researchers carried out a participatory rural appraisal to identify the most pressing problems affecting farmers in Gununo (see PRA report, 1997). The team, which included agronomists, soil scientists, economists and foresters, worked with extension agents from five different governmental and non-governmental institutions, using various PRA tools to facilitate discussions about natural resource management. When asked to identify and prioritise major problems, farmers produced the following list:

1. Unpredictable weather
2. Shortage of oxen
3. Soil erosion
4. Rising price of fertiliser
5. Declining soil fertility
6. Shortage and non-availability of improved seeds.

Gununo is prone to soil degradation, because of its location on a relatively steep slope, the high intensity of rainfall and intensive farming practices used in the site. Three of the six major problems listed by farmers are related to these factors.

After a series of exercises in stratified wealth ranking (see Table 1) and social analysis, twenty-four farmers were selected and invited to participate in research into natural resource management, to be carried out in partnership with AHI. The team used participatory research techniques to test various methods of improving soil fertility (Stroud, 1993, Pretty et al., 1995). Trials with crop varieties were used as entry points in establishing a partnership with farmers, who could choose from a series of high yielding varieties developed at research institutions in similar agro-ecological zones. During the course of experimentation, researchers monitored the selection criteria and methods used by farmers to maintain trials and disseminate technologies, classifying them according to the socio-economic status and gender of each participant.

A farmers' field school on legume cover crops (LCC) was set up after discussions with farmers, so that they could evaluate their agronomic performance under local conditions. Of the seven species studied[1], *Trifolium, Stylosanthus* and *Vetch* were already used to improve fallow and as a fodder crop in some parts of the Ethiopian Highlands. The other four species, *Canavalia, Mucuna, Croletaria* and *Tefrosia*, were included in the trials because they were found to be effective in other AHI benchmark sites in Kenya and Uganda.

Some of the information on soil conservation techniques was based on analysis of secondary data collected by the Soil Conservation Research Programme (SCRP), which worked in the same site. AHI also monitored the organic resources available to farmers from different social strata, using resource flow diagrams and weekly records of the production and use of organic materials by selected households.

[1] Trifolium (*Trifolium quartinianum*), Stylo (*Stylosanthus guianensis*), Croletaria (*Croletaria ochroleuca*), Mucuna (*Mucuna pruriens*), Tephrosia (*Tephrosia vogelii*), Vetch (*Vicia dasycarpa*) and Canavalia (*Canavalia ensiformis*).

2 The case study site

Location, climate and soil

Gununo is situated on an undulating slope that is divided by steep v-shaped valleys with intermittent seasonal streams. At between 1880 and 1960 metres above sea level, this area has mean annual rainfall of about 1300 mm, and an average temperature of 19.5º C. Rainfall is bimodal, with a short rainy season (*belg*) from March to June, and the main rainy season (*meher*) from July to the end of October. Most rain falls in July and August, causing soil losses of 27 to 48 t/ha (SCRP, 1996).

The dominant soils in the study area are Eutric Nitosols, which are characterised by high concentrations of nutrients and organic matter in the top few centimetres of the soil horizon. These acidic soils originated from kaolinitic minerals with inherently low levels of nitrogen and phosphorus (Waigel, 1986). Farmers identify and classify soil types primarily on the basis of crop yield, organic matter content, colour, workability, soil texture, land use systems or crops grown, location and distance from the homestead.

Farming systems

Agriculture is the main source of income in the area, where the farming system is characterised by small-scale production of mixed crops and livestock. On average, households in this area keep fewer livestock than elsewhere in Ethiopia. In the mid 1980s, the average household kept 7-8 head of cattle, but this has since declined to 1-2 head per household, because of shortages of feed, the conversion of grazing areas to farmland, the forced sale of livestock to pay off taxes and debts, and losses from disease (Farm Africa, 1992). Less than 15% of households now own oxen.

A very high population density of around 450 people per km^2 has reduced the average land holding in Gununo to about 0.25 ha per household. High population pressure has forced farmers to cultivate steep areas that used to be earmarked for grazing or tree plots. Young men used to inherit land from their parents when they got married, but this rarely happens now that households have such small holdings. As a significant proportion of the community is landless, many young people, who are among the worst affected, move to other parts of the country to work as labourers, and those who remain often sharecrop and rent land. Although land is still being redistributed in northern Ethiopia, this has stopped in the Wollayta zone, where land use is based on perennial crops and holdings are very small. Of all the AHI benchmark sites, Areka has the poorest infrastructure and worst access to markets for farm products. About 90% of households experience food shortages for at least two out of every twelve months, even in years with a relatively good harvest.

A participatory wealth ranking exercise undertaken in the study site identified five categories of household, defined according to the size of land holding, number of livestock, perennial crops grown and sources of income. About 18% of all households in Gununo fall into the category I, 18% in II, 23% in III and 41% in wealth strata IV (see Table 1). Category V was not taken into account as these households were no longer involved in farming.

Table 1. Results of participatory wealth ranking exercise, Gegecho zone, 1997

Strata	*Indicators of wealth*
I	These households are never short of food, and have enough money to buy clothes and other necessities. They have at least 1 ha of land and own more than 2 oxen, 3 milk cows, 3 sheep, 1 donkey and chickens. They also have many mature enset (see Box 2) and coffee plants in their homestead gardens.
II	This group has enough food to cover its needs (although reserves are limited), at least 0.5 ha of farmland, 1 ox, 1 milk cow, 1-2 sheep, 1 donkey and chickens. They have fewer mature enset and coffee plants than those in the first category. Some members of this group are traders.
III	Farmers in this category have 0.5 ha of land. They share ownership of 1 ox, 1 cow and 1 donkey, and may have 1-2 sheep and a few chickens, with a few immature enset plants and some coffee. They often buy maize in nearby towns to sell on in their own area.
IV	This category has very small plots of less than 0.3 hectares, a few coffee and young enset plants (1-2 years old) and some sweet potatoes. They have no livestock except for chickens, and earn most of their income from buying and selling maize flour, ginger, vegetables, salt, tobacco, etc. in the locality.
V	With neither land nor crops, these are the poorest of the poor who lost their land because they could not repay their debts. This group includes the weak, sick or elderly who have little available family labour, and daily labourers: women who scrape enset, fetch water and cut and carry grass for others, and men who collect fuelwood for sale in nearby towns, cut and split big trees and sell their labour to buy food.

Key: *I = richest, V = poorest*. The information is based on interviews with four farmers from each stratum

Land use and soil fertility management

Land holdings in Gununo are consolidated, unlike those in the northern highlands of Ethiopia, where fragmentation is the norm. Multiple cropping practices, such as intercropping and relay cropping, are common, thanks to the longer growing season resulting from the bi-modal rainfall pattern. Farmers in Wollayta generally divide their field into several plots, using each one for a different purpose, such as a grazing area, a coffee and enset field, a maize field, a sweet potato field, etc. The soil fertility status of each plot varies, with fertility levels declining the further the plot is located from the homestead. The outfields have the most depleted soils (Eyasu, 1998).

Homestead plots (*kareta*) contain the most important crops, such as enset, coffee and vegetables, and they are also used to raise planting materials for sweet potato and tree seedlings. As these plots are given continuous applications of manure, compost, household waste and ashes, their soils are high in organic matter and are generally dark brown to black in colour. With most of the available organic fertilisers used on the *kareta*, soils in neighbouring fields are red and less fertile, and generally require mineral fertilisers to produce a reasonable harvest. The main fields are used to grow maize, barley, wheat, teff, haricot beans and potatoes, and some plots are only used for ‘cut and carry’ fodder for livestock. Tethered animals graze the areas in front of houses (*deje*), which may also be planted with trees, as are the valley bottoms, steep areas, farm boundaries and gully areas.

Box 2. Enset

Enset (*Enset ventricosum also known as false banana*) is a carbohydrate-rich perennial crop, with a strong pseudostem and edible bulbs and corm. Grown as a staple and security crop, with most households in the southern highlands relying on this crop in the hungry season, it is harvested piecemeal throughout the year for its three main products:

- The corm, which is mainly boiled and eaten at home as *kotcho*
- The pseudostem, which is shredded and squeezed to separate the starchy *bulla* from the *kotcho*
- The leaves and midrib, which are chopped and fed to livestock, used as construction materials, fuel and as a mulch on enset, taro and maize crops.

Case study of resource-poor farmers

This case study focused on two farmers. Thirty-three year old Kassu Dand was responsible for feeding six people in the household. Lacking the inputs and oxen needed to farm his 0.30 ha holding, he decided to try sharecropping, and made the land available to colleagues with sufficient resources and available labour, in return for an equal share of the produce at the end of the season, minus the cost of mineral fertilisers. He did not actively participate in the research because he was not directly involved in managing his land, and also because he preferred to 'wait and see'. One point worth bearing in mind with sharecropping is that while those working the land will want to maximise their harvest, they are less likely to be interested in the future productivity of the soils.

Demeke was a twenty-five year old father of two, responsible for feeding seven family members. His holding measured less than 0.25ha, and was so highly degraded that hardly any crops grew on it, regardless of the amount and distribution of rainfall. With neither biological nor physical measures to compensate for a 20% slope, his land was subject to severe sheet and rill erosion, and had a soil horizon of only 20 cm, although similar fields in adjacent farms had horizons of up to 80 cm (Sheleme, 2000). Demeke had no access to farmyard manure as he only owned one donkey, which was used to transport retail goods to various markets. Analysis confirmed that the depleted organic matter content of the soil was the main constraint to agricultural production. Demeke earned most of his income from off-farm labour and retail trade, and in 1997/98, which was a drought year in Areka, he used all his resources to buy food. His family was at risk, and he was on the verge of leaving to look for work in the nearest gold mines in Shakiso, some 250 km from his home village. It was at this point that AHI started operations in Areka, looking for farmers interested in joining the research progamme. However, despite his desperate situation and willingness to try anything to improve his yields, Demeke was not very optimistic when invited to join the research on increasing soil productivity: '*I don't think it is possible to convert my exhausted land to a productive field. I will have to look for other living options. If you, however, insist that it may get improved I will advise my young brother to collaborate with you*'.

Both farmers had severely degraded land that could barely produce enough to feed their families, but they differed in their attitudes to soil fertility management. Mr Demeke was about to give up farming as he was virtually unable to grow anything, while Mr Kassu could still produce some crops, although his yield was much lower than that of better managed farms in the neighbourhood. Unless he implemented soil conservation measures and started applying soil fertility amendments, his land was likely to become as depleted as that of Mr Demeke, and we were interested whether findings from the actual situation of degradation would convince him of the need to change his soil fertility management strategies[2]. He may now lack the specific knowledge needed to identify indicators of degraded soils and assess trends on the farm, so he may assume that conservation measures are unnecessary because yields have not fallen significantly, even though the soils are in fact becoming increasingly depleted. Apart from soil fertility, other factors also have a considerable impact on subsistence farming, such as pests and diseases, the availability of high yielding varieties, and lack of animal traction, which can delay planting.

[2] Research in the Colombian Andes showed that although all farmers observed soil erosion on their farm and over 95% believed that soil erosion leads to lower yields, only 13% saw declining soil fertility as a major constraint to production (Mueller-Samann et al., 1999).

3 Approaches to restoring soil fertility

Building soil structure

Legume cover crops

Swift and Woomer (1993) argue that the main constraint to the sustainability of smallholder farms is their depleted soil organic matter content. Tests on soils from degraded fields in Gununo confirmed that they were badly affected by this problem. This also limits the response of crops to mineral fertilisers. These inputs are more effective when the organic matter content of the soil is increased, as this makes more soil moisture available, reduces nutrient loss from leaching and denitrification, and increases microbial activity.

In order to address the problems caused by low levels of soil organic matter, AHI researchers set up a farmers' field school on legume cover crops (LCCs), aimed at introducing farmers to various LCCs and evaluating their performance under local conditions. A group of three farmers with fields of differing soil fertility status started testing seven LCCs: *Trifolium*, *Stylosanthus*, *Croletaria*, *Mucuna*, *Tephrosia*, *Vetch* and *Canavalia*. The best-endowed farmer, who owned livestock and had relatively fertile land, preferred *Stylosanthus* and *Vetch*, while the other two farmers, who had fewer resources, opted for *Croletaria* and *Canavalia*. Table 2 presents the results of using LCCs from a better-off farmer.

Table 2. The performance of LCCs as short-term fallow on relatively fertile soils and their effect on soil moisture content (LCCs harvested after 6 months)

Species	*Fresh yield t/ha*	*Dry matter t/ha*	*Soil water %*
Croletaria	23.3	9.2	14
Vetch	3.7	1.0	21
Mucuna	19.3	5.2	23
Canavalia	13.5	3.8	14
Tefrosia	32.3	13.5	12
Stylosanthus	8.0	2.8	20
Undisturbed soil	–	–	17

Demeke was willing to try all seven LCCs on his farm, while Kassu wanted to see their effect on other people's land before trying them himself. Symptoms of aluminium toxicity had been observed on Demeke's maize crop, and it was common knowledge that the soils on his farm were severely degraded, so his neighbours watched the tests with considerable interest. The highest biomass yield was obtained from *Croletaria*, amounting to about 5t of dry matter/ha over four months, followed by *Canavalia* and *Mucuna*. *Tefrosia* performed best on the more fertile field of the better-off farmer where the crop could also be sustained for a longer period (Table 2).

Participating farmers were asked to evaluate the performance of the LCCs, and after intensive discussion they agreed on seven indicators: the root system, establishment of the crop, biomass production, resistance to drought, decomposition rate of green manure, effect on soil moisture, and fodder value (Table 3). The importance attached to each indicator varied according to the socio-economic status of the farmer assessing it. Poor farmers with very few livestock preferred LCCs such as *Croletaria* and *Mucuna*, which produce biomass quickly and can be used as green manure, while livestock owners favoured fast-growing legumes that can be used as fodder, like *Vetch* and *Stylosanthus*. Farmers with steep fields affected by erosion found *Mucuna* and *Canavalia* best suited to their needs. Overall, they preferred *Croletaria*, as it performed well on both fertile and degraded soils. Opinions of farmers and researchers may differ. Farmers, for example, observed that *Mucuna* helped increase levels of moisture in the soil (Table 3), while research showed that plots with *Stylosanthus* and *Vetch* also had substantially raised soil moisture levels (Table 2).

Table 3. Farmers' criteria for selecting legume cover crops

Species	*Firm roots*	*Early soil cover*	*Biomass*	*Rate of decomposition*	*Moisture conservation*	*Drought resistance*	*Fodder value*
Croletaria	2	6	6	6	2	2	2
Vetch	1	5	5	4	1	1	6
Mucuna	6	4	3	3	6	6	4
Canavalia	5	3	4	1	4	5	2
Tefrosia	3	2	2	2	5	3	2
Stylosanthus	4	1	1	5	3	4	5

Key: 6 is the highest score and 1 the lowest

All test LCCs were chopped and incorporated into the plot where they were grown. Demeke planted sweet potato during the short rains of the 2000/2001 season, and was hoping for a better harvest in view of the fact that the plant stand was much more vigorous after the legumes had been incorporated into the soil. Sweet potato performed best where *Croletaria*, *Stylosanthus* or *Mucuna* had been grown, possibly because they decompose faster than the other legumes.

As there is a serious shortage of land in Areka, farmers may be unwilling to allocate a full growing season for LCCs, and may not want to grow them in the relatively fertile enset and *darkua* fields, which are used for intercropping and relay cropping. The most likely niche for integrating LCCs therefore seems to be the outfield (*shoka*), where small-seeded cereals are grown in rotation with maize. The AHI-Areka team is currently conducting participatory research into the possibility of integrating these legumes as relay crops with short-term fallow to improve exhausted outfields.

Crop residue management

Since most producers in the subsistence farming systems of Gununo cannot afford mineral fertilisers, they need to restore soil fertility and reduce nutrient loss by incorporating crop residues into the soil or using them as mulch. We have already noted that soil fertility decreases the further the plot is located from the homestead. This is mainly due to the way that farmers manage their crop residues, which are needed for a variety of uses, such as feed for livestock, fertilisers and fuel (see Table 4). A typical feature of the farming systems in Areka is that all crop residues are removed from the outfields and used in the livestock pen or homestead garden. Some of the residue from cereals (wheat, barley and teff[3]) and legumes (haricot beans, peas and faba beans) is stored in the home compound and sold as fodder or used to feed livestock during dry spells, while the rest is used as mulch in the enset/coffee field in the home garden.

Table 4 illustrates the great diversity in crop residues used by richer and poorer farmers. It shows that maize and sweet potatoes produce the most crop residue, but little is used to restore soil fertility. Maize leaves are eaten in the field by livestock, while the stalks are mainly used for fuel, and as sweet potato vines can profitably be sold for planting material, only the fallen leaves are left to mulch the fields. The main factor determining the way that each wealth group uses crop residues is the number of livestock on a farm. Wealthier farmers use most of their wheat, barley, teff, bean and pea residues as fodder, and then spread the resulting manure on enset/coffee fields, while poor farmers use these crop residues as mulch on the enset field.

Farmers grow maize as their staple crop, relying on enset to carry them through periods of scarcity[4]. To develop well, enset requires fertile soils with a good organic matter content. Most crop residues and manure are applied to the enset field in home gardens, and previous research in a neighbouring district showed that these fields are the most fertile parts of the farm, particularly in terms of organic matter and nitrogen content (Eyasu, 1998). However, this study also found that excessive applications of organic matter may cause nutrient deficiencies, as a very high C/N ratio immobilises nitrogen for long periods, making it unavailable to intercrops. These fields would probably be more productive if organic matter was applied every other year, supplemented by P and K mineral fertilisers, which are usually only used on *shoka* fields.

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[3] *Eragrostis abyssinica*

[4] Local people see enset as the key to food security, although current research on human nutrition in Wollayta seems to indicate that maize covers the food supply for most of the year, and that enset is less crucial than generally assumed.

Table 4 . Different uses of crop residues by farmers from wealth groups I and IV

Wealth group	*Crop*	*Crop residue (kg)*		*Use of crop residues*	
		Farmer A	*Farmer B*		
				(Use is similar for farmer I-A and I-B)	
I	Wheat	32	18	60% mulch, 40% feed	
	Teff	27	488	60% feed, 40% sale	
	Maize stalks	25	450	80% fuel	
	Sweet potato	240	n.d.	95% planting materials	
	Enset	n.d.	n.d.	50% feed, 30% mulch	
				(Farmer IV-A)	*(Farmer IV-B)*
IV	Wheat	9	4.5	80% mulch, 20% feed	100% mulch
	Maize stalks	39	39	70% fuel	80% fuel
	Sweet potato	120	60	90% planting materials	90% planting materials
	Beans	9	4.5	80% animal feed, sale	n.d.

Key: n.d. = no data

This indicates that farmers may be applying too much organic matter to enset, and that overall food production on individual farms could be increased by changing the way that crop residues are managed. AHI researchers are currently working with farmers to see how they can remove fewer crop residues from the outfield without jeopardising enset production. This involves reviewing the way that crop residues have been managed and distributed over the last few years, and how often organic matter has been applied to the same enset plants. Farmers are also being encouraged to use the same variety and planting dates for maize grown in the homestead and outfields, and then to compare the yields and soils from the two types of field, using local criteria such as soil colour, soil depth, types of weed and crop yield to classify soil fertility.

Crop rotation with legumes

Crop sequencing affects the entire soil-plant ecosystem by altering the quantity and quality of organic residues returned to the soil, the soil moisture reserve, the erodibility of soil and the availability of nutrients. Some crops, such as sorghum, have a negative effect on the following crop because they exhaust the nutrient and water reserves, while others, such as faba beans, improve the quality of the soil.

Farmers in Areka are aware of the benefits of rotating cereals and legumes, and cereals such as teff, wheat or barley are traditionally grown in rotation with pulses. Faba and haricot beans are also intercropped with maize, and it is not uncommon to find up to six different crops grown in one field. Farmers cited three reasons for rotating cereals with legumes. First, legumes are an important part of their cuisine; secondly, this type of crop rotation can restore fertility through N-fixation and residual organic effects on the soil; and finally, it also controls host-specific pests and diseases affecting legumes, such as stem maggot in beans.

There is a general consensus among farmers that maize needs less nitrogen when planted after peas or faba beans than when grown as a monocrop. This has been confirmed by research in central Ethiopia, which compared the after-effects of faba beans, red clover and alfalfa on the yield and nitrogen budget of the subsequent winter wheat crop. They found that wheat took up 18kg, 47kg and 65kg N/ha after faba beans, red clover and alfalfa, respectively. However, the wheat only recovered 24-44% of the potentially available nitrogen fixed by these crops. The rest was lost by leaching, which could have been reduced by growing the wheat in association with legumes or sowing it immediately after they were harvested (Jung and Kuchenbuch, 1989). Research by Getnet et al. (1991) showed that barley produced higher yields when grown after legumes than it did after a fallow period. In this trial, clover and vetch had the most positive effect on barley, possibly because in addition to the benefits of N-fixation, more crop residues were produced and incorporated in the soil.

Soil protection systems

The major objective of soil protection systems is to reduce soil losses from water erosion, either when soil is detached by raindrops or when soil particles are removed by run-off. These systems include measures such as maintaining soil cover and reducing the amount and velocity of runoff.

Soil bunds along contour lines

Indigenous terracing practices observed in Konso, Ethiopia and elsewhere show that mechanical methods of soil and water conservation play a vital role in sustainable agriculture in highland areas, especially when combined with biological measures. The Soil Conservation Research Programme (SCRP) tested the effect on run-off and soil loss in cultivated fields situated on a slope of about 14% of grass strips, graded bunds and levelled bunds[5] with barley, sorghum and maize crops (SCRP, 1996). Trials took place between 1987 and 1991, when rainfall ranged from 992 to 1446 mm per year. It was found that the main factors affecting levels of soil loss and extent of runoff are the amount of precipitation, the kind of crop grown and the type of soil conservation measure adopted. All the soil conservation measures tested produced significantly reduced runoff and soil loss. On average, runoff was lowest in areas treated with levelled bunds (17%), and highest in plots with graded bunds (45%) and grass strips (49%);

[5] Graded bunds include a drainage ditch that acts as a waterway to drain extended terraced areas, while the waterway on levelled bunds is not channelled. Levelled bunds are often affected by overflow during the months of high rainfall.

while less soil was lost from narrowly spaced cereals such as barley, than from the wider spaced cereals like maize and sorghum. However, the total annual amount and distribution of rainfall was a more powerful determining factor than the type of crop grown or conservation measure adopted. Over the years, runoff from barley protected by levelled bunds varied from 18 to 39%, and soil loss from 0 to 6%.

However, despite the fact that the SCRP site was located in the watershed area next to our research site (only 7 kilometres away), we saw very little evidence to suggest that these technologies were disseminated or adopted outside the experimental area. Few farmers in Gununo take measures to prevent erosion, even though it is a serious problem, particularly during the rainy season in July and August. Although the farmers in Gununo acknowledged the considerable potential of the measures proposed by SCRP to reduce erosion, they did not adopt them. There were two main reasons for this. With less than 0.25 ha of land per household, poorer farmers were unwilling to set aside part of their plot for soil and water conservation measures, while richer farmers would not have been able to use their oxen to plough the bunds using the layout suggested.

In July 1998, scientists from AHI-Areka met with farmers to discuss how these constraints could be overcome, and asked them to suggest how technologies could be modified and adapted to local needs. Together they decided to construct outward projecting soil bunds or benches[6] on arable land, an idea which was based on indigenous techniques. Farmers were shown how to construct physical and biological soil conservation measures to decrease the velocity of runoff. Those with degraded lands built soil conservation bunds, which they stabilised with elephant grass and/or multi-purpose trees.

The vertical distance between successive contour bunds was determined by the amount of land involved, the degree of the slope and the farmer's usual method of preparing land. Bunds were set further apart on milder slopes and where land was prepared with oxen rather than hoed by hand. Mr. Demeke decided to set his bunds 10 to 15 metres apart, as his land is situated on a slope of about 20%. In 1998, he had planted wheat on the lower side of his sloping field, but reaped a very poor harvest, despite applying about 25 kg DAP/ha. However, when he built a soil bund and then planted the plot with wheat again, his yield increased ten-fold. He attributed this to the new construction, which prevented both seeds and fertiliser from being washed away.

Natural drains and permanent pastures provide outlets for run-off water, which can be very high during heavy storms. However, conflicts sometimes arise when farmers on the

[6] In outward projecting soil bunds or benches, soil and other strengthening materials (such as small stones) are placed above the ridge. This helps reduce the speed of run-off and the risk of gullies forming on the ridge, especially on steeply sloping arable land. The bund should then be planted with fast-growing runner grasses to stabilise it as quickly as possible. This technique is based on the local practice of constructing two adjacent soil bunds of different heights, so that the upper one stops the sediment and the lower one catches the overflow and directs it into the main waterway.

lower side of the sub-catchment are affected by the water management system used on the upper side of the catchment. Participating farmers agreed that common waterways need to be managed collectively as outlets, which would also improve the potential for water harvesting during dry spells.

AHI researchers proposed various combinations of plants to stabilise bunds, such as enset/banana, Elephant grass, *Gravillie*, and a combination of Elephant grass and *Gravillie*[7]. Elephant grass proved most successful when the efficiency of these plants as biological stabilisers was tested. Because enset and banana grew very slowly in the first two seasons, they could not prevent the bund from being washed away, and farmers were also worried about their roots spreading into the rest of the farmland, while *Gravillie* proved insufficiently drought resistant and grew poorly in the infertile soil. An additional benefit of Elephant grass was that it also provided fodder, and Demeke managed to earn up to 40 birr a month using it to fatten bulls for slaughter on the holy day of *Meskel*.

Minimum tillage

Ethiopian farmers till the land with ox ploughs, using the local *maresha* to prepare seedbeds and control weeds. According to traditional wisdom, well-tilled soils produce higher yields, particularly for teff, so they aim to till several times a year, regardless of slope or crop type. In Gununo, fields are cultivated and hoed throughout the year to get the most out of the small land holdings and available rainfall. As excessive tillage is known to aggravate soil erosion, AHI researchers conducted experiments to determine how often farmers need to till to produce a good harvest. Preliminary results showed that cereals with larger seeds, such as maize, produced better yields when tilled less frequently. As well as improving soil and water conservation, minimum tillage could have other advantages in a community where many farmers are short of oxen, reducing labour requirements and the costs of hiring oxen. In the next season, AHI is planning on-farm experiments with improved ploughs and donkey traction, in conjunction with agricultural mechanisation experts from the Ethiopian Agricultural Research Organisation.

Using crops to protect the soil

The root structure of some annual crops can help reduce soil loss, while the canopy structure of species such as melon and sweet potato provides soil cover, lessening the destructive impact of rainfall and runoff. SCRP spent several years testing the effect of various types of land management on run-off and soil loss on different slopes and types of fields in Gununo (SCRP, 1996). They found that soil loss from grasslands was minimal, even on steep slopes (40%), but short-term fallow had little effect in reducing run-off or soil loss. Frequently hoed plots are extremely vulnerable to erosion, even when rainfall is not very intense, while land planted with wider spaced crops, such as maize or

[7] Gravillie (Gravillie robusta), Elephant grass (Pennisetum spp.).

sorghum, is slightly less susceptible. Wide-canopied species like beans and sweet potato are most effective in reducing soil loss. Farmers in Gununo select their crops according to how vulnerable the field is to erosion, which is why Demeke planted sweet potato on the steepest corner of his land, sometimes rotating it with beans.

Evaluating soil fertility management measures

The various soil fertility management technologies selected and introduced by the AHI-Areka partnership were evaluated and assessed by farmers from various wealth categories. When asked to list the advantages and disadvantages of each technology, they acknowledged their effects on soil fertility, conserving moisture and reducing erosion, as well as recording occasional increases in yield. The main disadvantages were having less land available for cultivating crops, less availability of fodder crops and fuel, and the extra labour or effort involved in ploughing (see Table 5). There was little variation in the views of farmers from different wealth categories, although poorer farmers were more concerned about losing space that they would otherwise have used to grow crops.

Despite experiencing problems with degraded soils and food insecurity, and acknowledging the potential benefits of certain technologies, many farmers in Areka may decide not to integrate these techniques into their production system. Soil conservation measures often reduce the amount of available farmland and incur additional costs. In Areka, where land holdings are very small, every inch matters, so any loss of land means that farming has to be more intensive. Another constraint is the shortage of labour for constructing bunds. Farmers normally have time to construct soil bunds in the off-season, but this is also the hungry season, when many poorer households experience food deficits[8]. As a result, they are often too weak for the hard labour involved in digging and transporting stones and soil. Farmers with sufficient food reserves stay on their land, but those without often have to take off-farm jobs in order to survive. Land tenure is another factor affecting soil fertility management, as landowners have much less influence on how their land is managed when it is cultivated under a sharecropping arrangement, and sharecroppers may be unwilling to implement soil conservation measures as they are unlikely to reap any immediate benefits from them.

More farmers may be willing to adopt soil and water conservation measures if they provide immediate additional benefits, such as the potential to generate extra income. AHI observed that some farmers were implementing technologies in parts of the watershed that were not involved in the programme, so researchers identified and interviewed a group of 11 'non-AHI farmers'. This group of farmers worked steeply

[8] In Wollayta, the hungry season falls between March and June. There are two possible reasons which explain why poor farmers experience food shortages so soon after the harvest. Firstly, farmers often have to sell over half their produce immediately after harvest to pay debts, taxes, etc. and secondly, yields in the short rainy period are relatively low.

sloping fields (>20% slope) and had serious problems with erosion, which they were combating with bunds stabilised with Elephant grass rather than soil bunds *per se*. Elephant grass not only stabilises soil bunds, but is also an important source of fodder during the dry season, which can even be sold. When the dry spell lasted for about three months in 1999/2000, Elephant grass was the only green feed available on the ground in Areka, and AHI was praised for introducing it in the zone.

Table 5. Perceptions of integrated soil fertility management measures according to different socio-economic groups

Practice	*Wealth group I*		*Wealth groups III &IV*	
	Advantages	*Disadvantages*	*Advantages*	*Disadvantages*
Legume cover crops	• Enhance soil fertility • Provide fodder • Conserve soil moisture	• Compete for land • No immediate benefit	• Protect soil from sunlight and runoff	• Occupy space for long time • No food value
Crop rotation	• Enhance soil fertility • Less fertiliser requirements • Pest control	• None	• Enhances soil fertility • Improves yield	• None
Incorporating crop residues	• Improves soil fertility • Increases yield	• Shortage of animal feed	• Improves soil fertility	• Shortage of fuel and fodder
Soil bunds	• Reduce runoff • Possible to plant grasses & perennials	• Require a lot of labour • Ploughing with oxen difficult	• Erosion control	• Require a lot of labour • Take up land
Increased vegetative cover	• Controls runoff • Provides fodder and fuelwood • Provides litter for green manure	• Makes it difficult to control perennial weeds	• Increases availability of fodder • Controls runoff	• Competes for land and moisture
Mulch	• Conserves moisture • Improves soil fertility	• Reduces supply of fuelwood and fodder	• Conserves moisture • Improves fertility	• Attracts termites
Minimum tillage	• Reduces labour and costs • Reduces erosion	• Hard to control weeds • Crops establish poorly • Hard to cultivate	• Reduces cost of hiring oxen	• More weeds • Crops establish poorly • Crop selective

4 Discussion and conclusions

Working in a participatory way

Our main achievement in Gununo has been to increase the capacity of farmers to solve their problems through experimentation, and to encourage various organisations to work together and learn from each other. Using a participatory approach to research has been a very positive experience for AHI[9], helping the team identify problems and develop technologies that are better adapted to local conditions.

The 'farmer research group' established in 1999 has played a major role in identifying technologies and disseminating results through local organisations, such as the *debo*[10]. Farmer research groups are a local institution, established to facilitate research and credit schemes, and to instigate collective action. Some members also lobby policy makers, as their work with local government enables them to challenge policies on inputs, credit, etc. Farmer research groups can also suggest priority research areas and facilitate partnerships between AHI stakeholders.

We have had particularly good results with our work introducing new varieties and soil conservation measures, identifying sources of fodder and managing organic resources. The farmers' field school on LCCs raised awareness of the potential of various crops and how they might be integrated into farming systems. It also enabled farmers to evaluate their performance in their own cropping systems. About twenty-two farmers tested one or more LCCs on their farm in the 2000 season.

However, it is important to choose appropriate entry points. Although research into natural resource management needs to take a holistic view, acknowledging the complexities and diversity of farming systems, research with farmers should focus on clear issues, addressing problems that they have identified and prioritised. Although farmers generally opted to test different crop varieties, we found that if there was little initial interest in such trials, they were unlikely to try out any other natural resource management interventions.

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[9] AHI has appointed a regional research fellow, who is an expert in monitoring and evaluation. Indicators for assessing the effectiveness of participatory research were developed at a monitoring and evaluation workshop held in October 1999, and the research fellow is currently testing them in different sites.

[10] A debo is a group of people of a particular age that come together to work whenever one of their members is critically short of labour on the farm.

It is also important to remember that many farmers have already been exposed to 'improved' technologies, demonstrations and research. They may well have been discouraged by previous experience with high input systems or large-scale but poorly managed soil conservation programmes, which had limited results and left them with the impression that it is very difficult to improve yields.

The next step is to move from discipline-based research towards research and development in integrated natural resource management at watershed level, and to develop methodologies and processes that may be useful for other regions and countries. We are able to do this largely because we have the privilege of being supported by international and national research centres.

Scaling-up

The participatory approach has also facilitated initiatives to scale up the process and disseminate the results of research, as we have built up genuine partnerships with different stakeholders, including farmers, research institutions, the ministry of Agriculture, agricultural colleges and NGOs. Policy makers from the ministry of Agriculture participated in AHI field days and planning meetings, and are closely monitoring the AHI approach.

Work is also under way on institutionalising participatory research within the Ethiopian Agricultural Research Organisation (EARO). AHI organised workshops on participatory research for senior agricultural scientists from Ethiopia and Tanzania. As a follow-up, EARO set up five teams of scientists to evaluate the results of participatory research in the country, assess the effectiveness of this approach in promoting technologies, compare it with the conventional discipline-oriented approach, and identify problems associated with implementing participatory research.

Because AHI is part of an international network, the technologies and knowledge obtained from one benchmark site are tested in other benchmark sites, and the results presented and disseminated at regional and international fora.

The way forward

Soil degradation is a major constraint to agricultural production and food security in the southern Ethiopian Highlands. As their yields and incomes decline, poor farmers have fewer resources to invest in fertilisers or soil conservation measures, while pressure from the growing population forces them to cultivate marginal lands, discontinue fallow and stop using crop residues to maintain soil fertility. Soil fertility in the outer fields is declining most rapidly, as all crop residues from these fields are used on the homestead gardens, which also receive the bulk of manure and other organic waste as they are used to grow enset and coffee crops. There is thus considerable spatial and temporal variation in the extent to which arable lands are affected by soil degradation. Farmers need to adapt their soil fertility management strategies accordingly, focusing on restoring and maintaining the fertility of outfields and degraded fields on steep slopes. The five steps outlined below could be used as part of an integrated approach to restoring soil fertility:

1. Implement physical and biological measures to minimise soil loss caused by water erosion;
2. Increase soil organic matter content by incorporating crop residues and manure into the soil and growing legume cover crops;
3. Improve the water holding capacity of the soil by contour ploughing, minimum tillage and adding organic matter;
4. Increase soil nutrient levels with applications of mineral and organic fertilisers and by growing N-fixing legumes;
5. Use crop rotation, intercropping and relay cropping schemes to minimise losses and enhance fertility, with combinations of deep- and shallow-rooted crops, and by growing soil enriching species with those that deplete the soil.

In view of the fact that we identified five socio-economic strata in the area, each with clearly different opportunities and needs, blanket recommendations or technology packages are unlikely to provide effective solutions to the problems faced by farmers. Their interests will best be served by using a participatory approach to developing technologies that address the needs and specificities of each group, and by ensuring that farmers are fully involved in all stages of the process, from research and implementation to monitoring and evaluation.

References

Eyasu Elias, 1998. Is soil fertility declining? Perspectives on environmental change in southern Ethiopia. Managing Africa's Soils no. 2, IIED, London.

Farm Africa, 1992. Reports of diagnostic survey in Hanze and Fagena Matta Peasant Associations in Kindo Koysha. SOS Sahel, Farm Africa and Ministry of Agriculture. Environmental Protection and Development Programme.

Genet Assefa, Lulseged Gebrehiwot and Tadesse Teklethadik, 1991. Effect of forage legumes on the yield of subsequent cereal crops. Presentation at the Fourth National Livestock Improvement Conference, 13-15th November, 1991, Addis Ababa, IAR proceedings.

Jung, J. and Kuchenbuch, R., 1989. Nitrogen balance of legume-wheat cropping sequence. Acker-Pflanzenbau, 162(1): 1-9.

Mueller-Saemann, K., Floerchinger, F., Giron, L.E., Restrepo, J. and Leihner, D., 1999. In: Fujisaka, S., (ed). Soil conservation strategies that take into account farmer perspectives. Systems and farmer participatory research, CIAT publications No. 311, Cali, Colombia, pp. 76-85.

Participatory Rural Appraisal Report, Areka, 1997. Unpublished document. AHI, Ethiopia.

Pretty, J., Guijt, I., Thompson, J., and Scoones, I., 1995. A trainer's guide to participatory approaches, IIED, London.

Soil Conservation Research Programme, 1996. Data base report (1982-1993), Series II: Gununo Research Unit, University of Berne, Berne.

Stroud, A., 1993. Conducting on-farm experimentation, Centro International de Agricultura Tropical (CIAT), Cali, Colombia.

Swift, M.J. and Woomer, P., 1993. Organic matter and the sustainability of agricultural systems: definition and measurement. In: Mulongoy, K. and Merck, R.,(eds). Soil organic matter dynamics and sustainability of tropical agriculture, Chichester, UK, pp. 3-18.

Waigel, G., 1996. 'The soils of Gununo area', Soil conservation Research Project (SCRP), Research report 8, University of Berne, Berne.

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