

POLICY & RESEARCH SERIES

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**Soil Fertility
Practices in Wolaita
Zone, Southern
Ethiopia: Learning
from Farmers**

Editors:

Barry Pound & Ejigu Jonfa

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FARM-Africa's **Policy and Research Series** encapsulates project experiences and research findings from its grassroots programmes in Eastern and Southern Africa. Aimed at national and international policy makers, national government staff, research institutions, NGOs and the international donor community, the series makes specific policy recommendations to enhance the productivity of the smallholder agricultural sector in Africa.

FARM-Africa's **Farmers' Research Project** aimed to increase the incomes of resource poor farmers in Ethiopia by promoting the use of farmer participatory research as a mechanism for generating and disseminating improved and appropriate agricultural technologies.

About the Editors

Barry Pound is a livelihoods and farming systems specialist with the Natural Resources Institute. He is particularly interested in participatory approaches to natural resource management, and the interface between farmers, research and extension. He has been associated with the Farmers' Research Project as an external reviewer and consultant since 1993.

Ejigu Jonfa was the Project Co-ordinator for the Farmers' Research Project, and is now a member of FARM-Africa's Training and Advisory Unit in Ethiopia. He is keenly interested in the institutional aspects of participatory approaches.

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A CD, containing the full text of all the Technical Pamphlets on which this series is based, is available with this publication.

Executive Summary

The Farmers' Research Project and its collaborators used a range of participatory and conventional tools to study local farming practices including participatory rural appraisal, surveys of rural people's knowledge and experience, and soil analysis. The results were published in a series of Technical Pamphlets, on which this publication is based.

The studies, conducted between 1991 and 1999, showed that the clearing of forests, removal of crop residues from the fields, land fragmentation, the reduction of fallows, overgrazing, low fertiliser inputs, inadequate soil and water conservation, the cropping of marginal land, and poor soil management have contributed to land degradation. This resulted in lower crop yields and livestock numbers, leading to reduced food security and increased poverty. Soil fertility decline is an expressed priority for farmers, as well as a concern for the government of Ethiopia and international agencies.

The decline in soil fertility has four root causes: The impoverishment of farmers due to high taxes and a lack of support to small scale farmers imposed by successive regimes; the lack of confidence that farmers have in land as a permanent asset; increased pressure on land due to increased population; a reduction in livestock numbers (and therefore manure) due to drought, disease, forced sale and lack of feed.

Ethiopian farmers have proved themselves to be very resilient to the decline in soil fertility and very adaptable to changing circumstances. This is mainly due to a high level of indigenous knowledge and its flexible application to short and longer-term challenges.

Farmers are able to differentiate between soils in their area, and have local names for different soil types. They are aware where each soil type exists, and are able to map the distribution of soils within their Kabele.¹ The characteristics used by farmers are mainly physical properties that directly or indirectly affect the performance and productivity of crops.

Farmers' knowledge of their soils and how to manage them is extensive. Farmer's soil classifications and their expertise in the use of local materials are valuable assets that can be used by extension services and research and training organisations to reduce or reverse soil fertility decline. However there is a disparity between what farmers know and what their resources allow them to do.

Fertiliser use in Ethiopia is low compared to many other developing countries due to cost, lack of credit, poor availability and the risk of crop failure. However, farmers use locally available materials and indigenous practices to maintain or improve soil fertility. These are applied in different ways to the various types of land and include: manuring, hoe cultivation, crop residue utilisation, use of leaf litter, composting, fallowing and soil conservation.

1. A Kabele is the equivalent of a parish.



Manure is one of the most important factors in ensuring consistent yields. However, nutrient balance trials show that in some cases manure could be used more effectively (especially in the lowlands) by applying a greater proportion to outlying (shoka) fields, rather than over-manuring fields located near to the homestead (darkua).

Inorganic fertilisers should not be seen as the solution to declining soil fertility. Even when farmers can access and afford meaningful quantities of the correctly balanced fertilisers they are only a partial solution. An integrated approach that combines a sensitive appreciation of the properties of different soil types combined with soil and water conservation, the effective use of manures, crop rotation, fallowing, crop residues and fertilisers has the best chance of arresting and reversing soil fertility decline.

By using farmer's soil classifications and increasing awareness of farming in Ethiopia a common language between land users, extension staff and researchers is formed. Meaning government and NGOs can support farmers and target recommendations for improved soil management with a range of options that provide choice to farmers with different levels of resources.

This publication draws on five Technical Pamphlets, derived from studies conducted as part of the Farmers' Research Project.

- Jonfa, E., Berhanu, T., Kano, K and Follo, F. (1997) Participatory Soil Mapping and Characterisation in Kindo Koysa, Southern Ethiopia. FRP Technical Pamphlet No. 13.
- Dea, D. (1997) Soil Fertility Management in Wolaita, Southern Ethiopia: An Anthropological Investigation. FRP Technical Pamphlet No. 14.
- Elias, E. (1997) Soil Fertility Management and Nutrient Balance in Kindo Koysa Farms: A Case Study in North Omo, Southern Ethiopia. FRP Technical Pamphlet No. 15.
- Tessema, W. (1998) Policies for Sustainable Soil Fertility Management in Wolaita, Southern Ethiopia. FRP Technical Pamphlet No. 18.
- Deribe, T., Tanga, D and Shola, L. (1999) Indigenous Technical Knowledge (ITK) Based on the Kabeles of Sulla Zakota and Wareza Gerera of Chench and Soddo Zuria Woredas of North Omo. FRP Technical Pamphlet No. 19.

Introduction to FARM-Africa's Farmers' Research Project

This publication is based on five studies conducted by FARM-Africa's Farmers' Research Project (FRP), based in North Omo zone² and Derashe and Konso special woredas³ of southern Ethiopia between 1991 and 1999. The FRP was a collaborative project with the Bureau of Agriculture, the Awassa College of Agriculture and the Awassa Research Centre (part of the Ethiopian Agricultural Research Organisation).

The main objective of the project was to sustainably increase the incomes of resource-poor farmers in southern Ethiopia and ultimately in Ethiopia as a whole.

The project promoted farmer participatory research as a mechanism for generating and disseminating appropriate agricultural technologies for rural men and women.

Farmer participatory research was seen to complement conventional research processes and the governments' Participatory Demonstration and Training Extension System. Farmer participatory research includes a thorough participatory situation analysis, participatory on-farm testing of technologies, greater collaboration between research and extension staff, and greater farmer participation in decision-making.

Participatory research tools used in the Farmers' Research Project were:

1. Diagnostic Surveys, which analysed the complex bio-physical and socio-economic situations of communities, and identified priority opportunities and constraints to be addressed through research and support mechanisms;
2. Participatory On-farm Trials in which researchers, extension staff and farmers work together to find solutions to priority problems;
3. Special Studies of important topics that bring together indigenous knowledge and scientists' knowledge.

FARM-Africa's Farmers Research Project also included training farmers, extension staff, researchers and policy makers in the approaches and methods of farmer participatory research.

From 1999-2003, a follow-on project 'The Institutionalisation of Farmers' Participatory Research in the Southern Nations, Nationalities and Peoples Regional State' extended participatory research activities into nine zones and five special woredas of the southern region of Ethiopia. This project facilitated the incorporation of the approaches, methods and tools of farmer participatory research into the regular activities of organisations involved in the generation and dissemination of agricultural technologies in southern Ethiopia.

2. North Omo zone has now split into three zones (Wolaita, Gamo Gofa and Dawro zones). Most of the work of the Farmers' Research Project took part in what is now Wolaita zone.

3. A woreda is an administrative unit equivalent to a district in other countries.

Soil Fertility Decline in Southern Ethiopia

Southwest Ethiopia covers 30,000 square kilometres and has a population of over 3 million. Many natural resource management factors combine to cause soil fertility decline in this area, these include:

- Clearing of forests
- The removal of crop residues from the fields
- Land fragmentation
- The reduction of fallows
- Overgrazing (even though livestock numbers have declined)
- Low fertiliser inputs
- Inadequate soil and water conservation
- Cropping of marginal land
- Poor soil management

These have resulted in lower crop yields and lower livestock numbers, leading to reduced food security and increased poverty. However, these are not the root causes of soil fertility decline, which our research shows to be:

- The impoverishment of farmers due to high tax and a lack of support given to small scale farmers by successive regimes;
- Lack of confidence that farmers have in land as a permanent asset;
- Increased pressure on land due to increased population;
- A reduction in livestock numbers (and therefore manure) due to drought, disease, forced sale and lack of feed.

Diagnostic surveys carried out using Participatory Rural Appraisal tools⁴ in Wolaita during 1991 and 1992, and using household questionnaires in 1997, identified declining soil fertility as one of the most important issues that constrain agricultural production in both highland and lowland areas of North Omo.^{5,6} These surveys led to the studies and findings described in this publication.

The methods used were based on the conviction that a clear understanding of the views, perceptions and practices of rural men and women are vital in exploring opportunities for improvement, and developing locally-informed solutions.

4. Participatory Rural Appraisal is a set of tools that enable researchers and extension staff to work together with men and women from rural communities in a participatory way to explore their environment, activities, practices, problems and opportunities. The FARM-Africa publication "Farmer Participatory Research and Extension Guidelines," edited by Ejigu Jonfa and Barry Pound (2002), gives further details of these PRA tools.

5. North Omo has now been divided into three administrative zones. The study reported here was conducted in what is now Wolaita zone. The other two main constraints mentioned were lack of draught oxen, and erratic rainfall.

6. In Chencha woreda the first six priorities identified were: 1. Scarcity of farm land; 2. Poor soil fertility; 3. Yield decline; 4. High price of artificial fertiliser; 5. Mole rats; 6. Shortage of livestock feed

The studies reviewed in this publication attempted to understand soil fertility from the farmers' perspective, and look specifically at:

- How farmers classify their soils;
- How historical events, resource access and socio-economic situations facilitate or hinder people's capacity for soil management;
- How farmers perceive soil fertility, and how this has changed over time;
- How farmers respond to changes in soil fertility.

The studies also consider soil fertility from the scientific perspective, particularly nutrient balances in different parts of the farm in the highlands and lowlands.

The decline of soil fertility remains a priority issue today, underlining the need for clear, practical information based on field work with communities, which identifies practical ways in which the information can be used by extension staff and research and training institutions.

Methods Used in the Studies

The soil fertility studies were all in Kindo Koysa woreda (Wolaita zone). The woreda contained Kebeles in lower (800-1100 metres above sea level), medium (1400-1900 masl) and high altitude (1500-2800 masl) situations.⁷

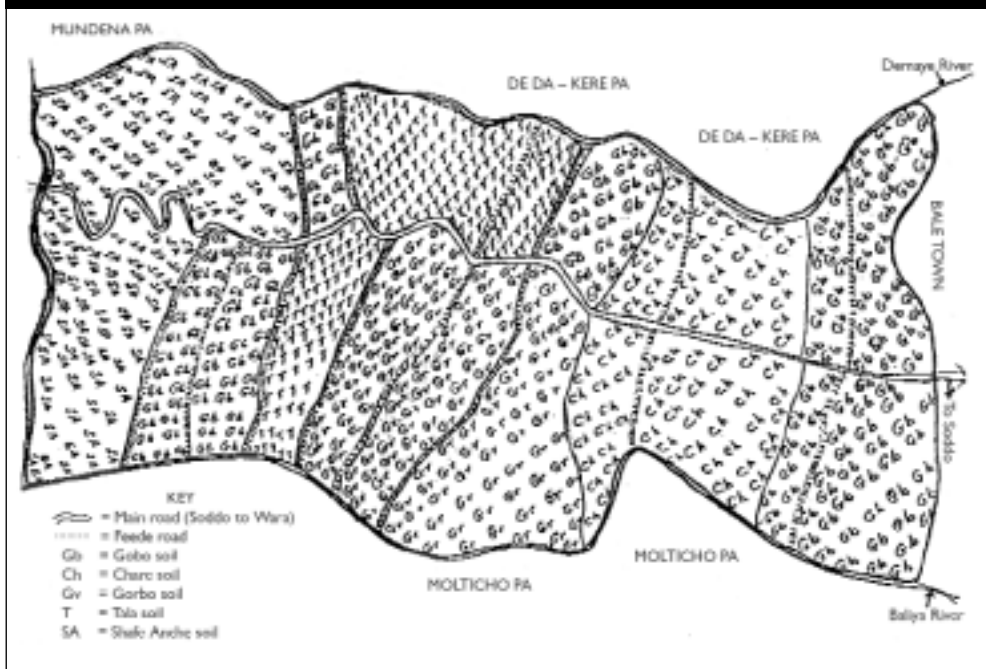
A further study on indigenous knowledge used two additional Kebeles: Sulla Zakota-Mafo in Chencha woreda of Gamo Gofa zone, and Wareza Gerera in Soddo woreda of Wolaita zone.

Participatory Rural Appraisal and conventional technical analysis methods were used. These include:

- Semi-structured interviews with male and female farmers, in which a discussion is held with a selected group using a pre-prepared check list of questions.
- Participatory mapping of locally-recognised soil types. Maps were drawn by farmers on the ground. Physical features and soil types were distinguished by using different materials. An example is given in Figure 2.
- Farm walks included discussions with farmers about the characteristics of different soils, altitude and topography and the incidence of erosion and vegetative cover.
- Wealth ranking where the whole population of a village is divided into three wealth groups (poor, medium and well off). This helps the division of families for separate discussions, so that differences between the wealth groups can be distinguished, and correlations between wealth and soil fertility identified.

7. The study Kebeles were Fagena Mata (lower altitude); Sorto and Fachana (medium altitude) and Doge Shakisho and Lasho (high altitude).

Figure 2. Soil map of Fagena Mata Peasants Association (Kebele)



- Questionnaire survey: 100 households, drawn on a proportional basis from each of the three wealth rank groups, were interviewed using a structured questionnaire.
- Nutrient balance studies were conducted for one year on case study farms chosen from each wealth rank group in the highlands and lowlands. In these studies farmers identified the main flows of nutrients purposely carried into and out of their farms.
- Participant observation where the researcher lives with the informants while interviewing, observing and recording their activities.
- Physical and socio-economic description of the study villages resulting from a review of secondary data, observation and informal questioning.
- Soil samples taken from each soil type identified by farmers during the farm walks, and from soil pits. The results from the analysis⁸ of the soil samples and pits were used to determine whether there were strong similarities between farmer's soil classifications and those of soil scientists.

8. The laboratory analyses carried out on the soil samples were: particle size distribution, organic carbon, total nitrogen and pH. Mussel's soil colour chart was used to describe soil colour.

The Soil Fertility Context

The historical and policy context

Before 1894, Wolaita had a strong, centralised political system and the region was fertile, wealthy and productive.

“Walayat (now Wolaita) is extremely fertile; numerous plantations of corn, wheat, barley, coffee, tobacco, cotton and millet surround the compounds of huts and make the country’s appearance rich. Vegetation is abundant with figs, palms, spindle trees, sycamores etc...skins of gazelles, lions or leopards hung in the inside of the huts show that hunting is a major activity. They are a happy population, very self-sufficient, still living a biblical style of life.”

Vanderheyem (around 1894), quoted in Chiatti 1984, pp 334-335.

However the losses of livestock and labour during the Derg regime, and subsequent taxes, undermined the agricultural base and brought the area into poverty.

There have been a number of initiatives aimed at improving agriculture over the last 40 years. The Wolaita Agricultural Development Unit (supported by the World Bank) promoted heavy use of external inputs such as fertiliser, improved seed, pesticides, credit, implements, oxen and land conservation, which increased productivity in the short term, but was not sustainable and appears to have impoverished some land in the longer term. The government’s two Minimum Package Programmes also promoted fertiliser, although the second had a “non-fertiliser” package that relied on better cultivation, cultural practices and improved seed to increase yield. Another initiative, the Peasant Agriculture Development Extension Programme, aimed to decentralise planning and policy formulation, but was hampered by financial constraints, policy reform and the civil war.

Land reform followed the socialist revolution in 1974, as a component of the policy of Agrarian Socialism. The newly established Peasant Associations were given the authority to allocate and redistribute land. Everybody was entitled to hold land, but on a usufruct basis. This shook people’s confidence in land as a permanent asset that one could invest in. The land reform proclamation also abolished the private ownership of forests, leading to massive destruction of natural forests. Other problems that affected production during this time were villagisation, the imposition of cooperatives and high grain taxes, as well as natural problems such as drought, pests and diseases of crops and livestock.

A rise in the rural population, particularly in the last 30 years, has resulted in an increased number of land claimants, some of which have used forests, steep mountain land or grazing land in which to establish their homesteads. Many others among the rural youth are landless.

The Ethiopian Peoples Revolutionary Democratic Front (EPRDF), in power since 1991, has made some steps towards decentralisation, popular participation and private investment. However, land tenure, despite its central role in peoples' willingness to invest in soil fertility improvement, remains an unresolved policy issue. Poverty reduction was seen as a central economic and social priority, with deforestation and land degradation (as components of diminishing agricultural productivity) identified as key constraints to alleviating poverty. The long-term strategy was defined as Agricultural Development-led Industrialisation, and incorporated the National Conservation Strategy – which evolved into the Environmental Policy of the Environmental Protection Authority.

The Sasekawa Global 2000 project started in 1993, and sought to increase food grain production rapidly through an aggressive extension programme based on inputs and credit. However, it was biased towards better-off farmers in higher potential environments, leaving poor farmers less able to access the benefits of the project.

The social context

The household is the basic unit of production, reproduction, consumption, decision-making and resource management. In male headed households decisions are made by the husband, but often after consultation with his wife. The size and age structure of the household influence decisions on land use, as each task has its own particular labour requirements, while household financial wealth affects the ability to invest in soil fertility enhancing measures requiring purchased inputs.

Settlement patterns have changed drastically over the last 100 years as the population has increased and migrated. There are strong kinship ties, which are important alignments in arrangements for share-cropping, share-breeding, labour exchange and security during a crisis.

The expenses related to marriage are a major reason for sale of livestock and land, hampering the socio-economic condition of many households (and reducing the build up of commercial units).

Traditional local institutions such as Idiria, Shufua and Bankia help families (especially the poor) to cope with funerals, house construction and savings. Savings used to be for buying land, but this has now lost some of its permanence. Similarly livestock have been seen as a poor investment due to the prevalence of disease and the cost of veterinary care.

The resource context: land, labour, livestock and cash

The three case studies included at the end of this section give insights into the historical and social context of land use. All three farmers quoted highlight their lack of oxen for ploughing and provision of manure.

Land tenure:

In the highlands of Wolaita most land holdings are less than 0.5 hectares and many people are landless. Land tenure has varied a great deal historically and after 1975 land reform entitled

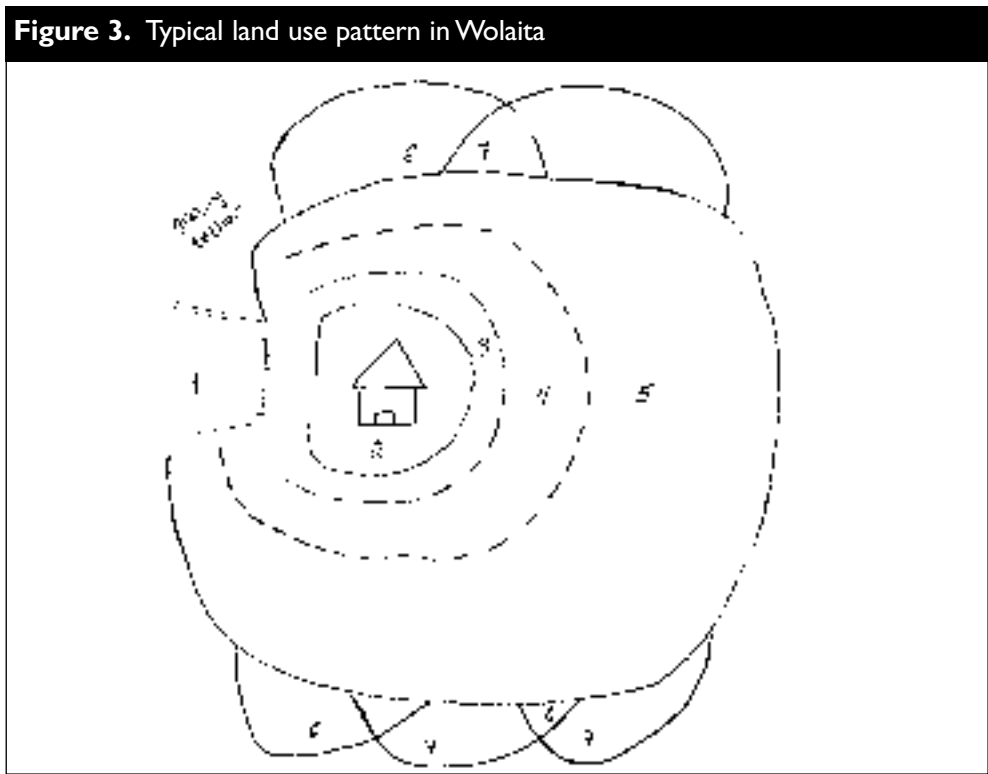
every household to usufruct access to land. However, due to the way this was handled, many did not feel that their land rights were secure. This is a disadvantage since people have to invest for decades to build fertility in the land near to their homestead (the darkua).

Land is now accessed in four ways, as the government has no more left to allocate

1. Inheritance, which is the main means;
2. Purchase, which, although strictly illegal as all land belongs to the government, still goes on – especially for those with high marriage or hospital bills to pay;
3. Through share-cropping. There is strong competition among those who wish to access land through share cropping, and landlords tend to favour those with a good record in land management. Share-cropping brings those with resource constraints (lack of land, lack of labour) together, and is also a way of strengthening social relationships;
4. By contracting. This is a recent development, where land is hired against cash payment for a specific period of time.

Land types:

The average farm in the highlands of Wolaita is divided into seven types of land, as shown in Figure 3.



1. Front Yard, 2. House Yard, 3. Darincha, 4. Darkua, 5. Out Field, 6. Grass Land, 7. Wood Lot. Broken lines indicate loose boundary.

The key land type is nearest the darkua (house), which the household is always trying to expand through improvement of soil fertility. This quest can be constrained by lack of labour or the scarcity of manure and other organic supplements. Crops such as enset (*Ensete ventricosum*), taro (*Colocasia* and *Xanthosoma* species), coffee and maize are grown on this land.

Unfortunately agricultural experts, such as government staff and others, do not use these terms, but instead use technical language such as agricultural land, forest/bush land and grassland. This classification does not encompass the integration of the farm parts or its dynamic which can cause confusion between farmers and agricultural experts.

“When my great grandfather came here all was forest. The dominant crops grown were sorghum, taro, enset and maize. With the Amharas came great hardship as they demanded heavy taxes in the form of food. We lost much of our land, but some was returned during the Italian occupation. In my fathers time much of the land was for grazing, but now there are many people with small, cultivated plots. The fertility in darkua areas is increasing, but in the shoka areas it is declining. Fallowing used to be common, but now all land is cropped in all seasons. Yields have declined due to poor fertility, poor rains and crop diseases. WADU (Wolaita Agricultural Development Unit) brought fertiliser, as a result of which yields increased. They also brought Service Co-operatives, which were a good idea, but when the Derg regime collapsed, the officials stole money. Now we cannot afford fertiliser, and we don’t have oxen or labour to manage the land well.”

Case study: Ato Altaye Anaro Balango, aged 80-90.
A rich farmer from Fachana Peasant Association.

Labour:

Labour shortage results in manure and compost resources not meeting their full potential. Manure management involves transport and incorporation, while compost should also be turned in the pit for highest results. Similarly, soil conservation work may not be carried out to the optimum technical specification due to shortage of labour for constructing or maintaining bunds or terraces.

“My father inherited good land as well as livestock. He worked hard at farming and trading, and became a rich landowner in Haile Selassie’s time. He fostered four boys to increase his labour force, and also called work parties of different types, known locally as dagwa, zayia and urpia. He was able to distribute land to his sons, but after the revolution daughters were not able to inherit. A few years after I inherited, land reform came and my land was reduced a lot. However, through good coffee trading I was able to buy more land and livestock. I have 3 wives and ten children, but still suffer from labour shortage. Fostering was disapproved of in the Derg regime, and dagwa is not viable as people demand too much food and drink. I still host some zayia for hoeing plots. Recently my livestock have been dying of disease, meaning that I have insufficient animals for ploughing and less manure than before. My wealth is declining and I am now only self-sufficient.”

Case study: Ato Geta Nasa Bala, aged 45. A medium-wealth farmer

Livestock:

Livestock numbers were severely diminished during the Derg regime. Currently they are limited by a lack of grazing facilities, as land is ever more intensively used for arable production which provides the staple foods necessary for family subsistence. Fewer livestock means less manure. This in turn means that less manure is available to bring fertility, structure and water-holding capacity to the soil. Reduced grazing land also means less fuel, and a greater proportion of dung having to be used for cooking.

Several joint-ownership and share-breeding arrangements (kotta, ulo-kotta, hara, wosa and gotua) are practiced between people of different wealth status, with a negotiated sharing of benefits. These are based on kinship ties and other social networks. These allow people to own at least a share in livestock, and to derive some benefits (food, manure, income) from them.

“My grandfather had a lot of land, but much of it was confiscated by a feudal lord. My father was only able to inherit a small plot of fertile land. However, his brother chased him off it onto an infertile plot, which I inherited. During land reform, I also acquired a small piece of fertile land. I have tried to improve the infertile plot, but labour shortage, oxen shortage and poor health have prevented me from doing so.”

Case study: Oda Orchile Sigo, aged 40.

A poor farmer from Fachana Peasant Association

Cash:

Cash is required to purchase land, livestock and inputs, and to hire labour. Sources of cash include the sale of farm produce, petty trading, craft work and off-farm activities. Off-farm employment has increased in importance as sales of crop and livestock products have decreased, and is particularly important for poor farmers in bad crop years.

How Do Farmers View and Classify Soils?

Farmers are easily able to differentiate between soil types in their area, and have local names for different soil types. Farmers consider soil as a living entity that grows, matures, becomes old and even dies so that even grass cannot grow. A 'sick' soil can be cured with the right inputs, and a 'tired' soil can be rejuvenated.

Farmers are aware where each soil type exists, and are able to map the distribution of each soil type within their own Kabele. At the household level farmers are also able to identify variability between soils at the field level.

Farmers often identify at least five different soils types in each Kabele, as shown in Table 1:

Kabele	Soils identified	Altitude zone
Doge Shakiso	Bossolo Kareta Talla (reddish and black) Bokinta Gobo	Higher altitude
Sorto	Salisatya Barta Gorbo Gobo (red and brown) Talla (Gobo talla, Gorbo talla and Aeka talla)	Medium altitude
Fagena Mata	Gobo Shafe-ancho Chare Gorbo Talla	Low altitude

Criteria used by farmers to differentiate between soil types

Farmers in all Kabeles studied were able to characterise each soil type separately. Some characteristics were unique to a particular soil type. The characteristics used by farmers were mainly physical properties that directly or indirectly affect the performance and productivity of crops. Soils were also classified by their colour, depth and thickness and by the nature of sub-soil or parent materials.

Farmers' characterisation of soils is based on colour, productivity, depth, workability, erodibility, behaviour under different soil moisture conditions and ability to sustain a diversity of crops, as detailed in Table 2.

Farmers generally consider the condition and character of the soil down to plough depth. However, they are also aware of the effect of soil characteristics below plough depth. Although farmers rank the best soils as those which require little input to enrich them, the current fertility of a soil depends very much on nearness to the home, and therefore the amount of manure received, and overall soil management.

Table 2. Farmer soil classification criteria, with examples

Soil colour

- Kareta Black
- Talla Black, reddish brown, red (depending on the Kabele)
- Bokinta Red
- Gobo Red
- Barta Whitish
- Gorbo Changes with depth
- Shafe-ancho Red
- Chare Brown
- Bossolo No colour mentioned
- Salisatyia No colour mentioned

Fertility

- Extent to which soil needs fertilisers and responds to them. Farmers rate Talla and Barta soils as highly responsive to fertilisers.
- Productivity or performance of crops and crop diversity. Farmers rate the following soils as having poor fertility: Bossolo, Shafe-ancho, Bokinta and Salisatyia.
- Gorbo soil was ranked first in Fachana and second in Fagenata Mata. It is suitable for almost all crops, and is not easily affected by heat, rainfall or drought.

Erodibility

- Farmers rate Bossolo, Barta and reddish Gobo soils as very susceptible to erosion.

Soil moisture

- Duration of moisture stress effects on crops.
- Soil moisture retention.
- Water movement in soil (percolation, infiltration).
- Soils in which crops wilt quickly are: Bossolo, Shafe-ancho, Bokinta and Gobo.
- Kareta retains moisture for a longer period after rains have stopped. Shafe-ancho and Chare soils become waterlogged during the rainy season, and are therefore often chosen for taro production.

Physical characteristics

- Talla soils crack and become sticky when drying, leading to stunted growth and pests.
- Gobo is finer than Bossolo, and Shafe-ancho and Salisatyia are coarse textured.

Depth of topsoil

- Gobo, Charia and Gorbo soils are deep, while Bokinta, Barta and Shafe-ancho are shallow.

Workability

- Talla and Chare soils are hard to plough in dry and wet conditions. Gobo, Gorbo and Barta are easily worked under any conditions.

The Wolaita perception of soil fertility is demonstrated in their description of fertile (arada) and infertile (lada) soils:

Arada soils: Found on gentle slopes, and have deep topsoil. They are described as black, rich, fat, strong, manured, near house and hoed. Arada soils are resistant to erosion, and have good water-holding capacity. Arada soils can become lada soils with poor management and vice-versa.

Lada soils: Found on steeper slopes, and are described as shallow, red, poor, thin, weak, not manured, far from the house and ploughed.

Scientists classify soils according to their chemical, physical and biological properties, which they relate to the parent materials from which the soil is derived. Scientists give soils names that are impossible for farmers and most development workers to understand.

For scientists to assess the properties of soils, samples have to be collected and taken to laboratories for analysis. This analysis can take months, whereas farmers can classify their soils on the spot from evidence at the time (colour, texture, productivity, moisture content) and knowledge of past performance.

Differences Between Highland and Lowland Soils

There appear to be real differences between highland and lowland soils. Farmers in the highlands claim that their soil is naturally fertile, but fertility has declined due to continuous cultivation, reduction in fertility inputs and drying of the soil surface.

In contrast, lowland farmers say that their soil was of low fertility when they started farming it, but they have built up fertility through intensive ploughing, organic manuring and crop rotation.

Soil samples were taken from soil under natural vegetation and crops. The results show that hill soils are, indeed, naturally fertile, apart from low levels of available phosphorus (3-4 parts per million). This phosphorus limitation is considerably improved (to 30-40 ppm of available phosphorus) when manure is added over extended periods because the phosphorus that was being chemically fixed now forms complex organic molecules that surrender their phosphorus to plants.

In contrast, lowland soils were found to be less fertile under natural conditions, and, although the addition of manure and compost helps to improve the levels of nutrients, cultivation has not been successful in raising nitrogen or phosphorus levels to those sufficient for good crop growth.

Factors Bringing About Decline in Soil Fertility

The decline in soil fertility has four root causes. The first is the impoverishment of farmers due to previous high taxes and little support to small-scale farmers. This has reduced the land, labour and livestock resources available to maintain soil fertility. The second is the lack of confidence that farmers have in land as a permanent asset. This has reduced their willingness to invest in long-term measures to improve soil fertility. The third is the extra pressure on the land due to increased population, as the same land has to support an ever-increasing number of people. During the time the World Bank supported Wolaita Agricultural Research and Development Unit, external inputs were able to compensate for the increasing population, but now production relies on natural fertility, which is being increasingly over exploited. The fourth component is the decline in the amount of manure available. Livestock numbers were reduced historically, and have recently been further depleted by drought, disease and forced sale to meet economic needs. In addition, livestock numbers are constrained by lack of feed as grazing land has been converted to cropland.

In the absence of significant amounts of external inputs such as fertilisers, the fertility of cropped soils depends on the replacement of harvested nutrients by manure and compost. The amount of manure added to soils declined from an average of 10-15 tonnes per hectare per year to 3-5 tonnes per hectare per year over 15 years to 1997. This had the predictable consequence of reduced crop yields leading to food insecurity, poverty and migration.

In the highlands, land shortage due to increasing population is a serious problem. Most farmers practice continuous cropping of their land even though they know it exhausts the soil through nutrient export and decline in organic matter. Crops are often grown alone with no intercropping or rotation with legumes.

Farmer's Responses to the Decline in Soil Fertility

Farmers are responding to the decline in soil fertility in numerous ways. Some are changing their social behaviour or adapting their farming system, whereas others are reacting through action to improve the soil itself.

Due to the decline in soil fertility, and consequent reduction in farm productivity and income, farming families are more reliant on off- farm activities to provide food and income. Emphasis is given to education for children, so that they can get out of farming and reduce pressure on the land.

Within farming, social arrangements are used to bridge resource gaps (land, labour, livestock and capital), such as sharecropping and share-breeding, and there is increasing use of early maturing crops to get more crops per season on the same piece of land (even though this is detrimental to soil fertility).

Farmers also use methods specific to maintaining and improving soil fertility, as shown in Table 3.

Soil fertility management activity	% of farmers using the practice
Inorganic fertiliser	73
Manure and household refuse	87
Residue return	50
Leaf litter	36
Composting	13
Fallowing	13
Termitarium soil	10

Inorganic fertiliser

Di-ammonium phosphate (DAP) is the most commonly used fertiliser. This is applied at planting. Urea is also used, mainly as a top dressing, particularly in the highlands. According to Belay (1997) in the text *Agricultural Extension Aspect of Soil Fertility Maintenance*, between 1971 and 1996 fertiliser sales to the smallholder farming sector rose from 947 metric tonnes to 236,275 metric tonnes. Yet rates of fertiliser used are significantly below those recommended by the extension services because farmers are looking for the highest return per unit, rather than the highest yield possible. Poor farmers can only afford a small amount of fertiliser, and are particularly careful that it is placed near to the individual plants to improve its efficiency.

Cost, lack of credit (most resource poor farmers are not eligible for credit) and poor availability are the main reasons given by farmers for the low rates of fertiliser used. Although theoretical calculations show a good financial return to the use of fertilisers at the recommended rates farmers are worried about getting into debt if they take credit. Fertiliser response is poor in years of bad rainfall, and farmers are reluctant to invest in such an expensive input if they feel that the risk is too high.

“I have 0.75 hectares of land, and I also share with my father by cultivating his land. I use 50 kg DAP taken on credit from the Bureau of Agriculture office against the harvest. Supply is sometimes delayed. Then I have to buy at high price from merchants. If I sow without fertiliser, the crops will die. Last year I used DAP, obtained on credit, but I didn't harvest due to crop failure because of drought. I had to pay my debt by selling livestock. Those who don't have livestock will give their land for contract to settle the debt. Some who cannot pay go to prison.”

A poor farmer from Fagena Mata

Some villages (e.g. Lasho) are against the use of fertiliser. They believe that the climate is not warm enough, their crops don't need it and that it might ruin their soils. In the lowlands, even well off farmers use low fertiliser rates, but high organic matter applications.

Manuring

As Table 3 shows, most farmers use manures and household refuse (sweepings, ash and food residues) in their soil fertility maintenance programme. Farmers say that manure improves fertility for a number of seasons, rather than just improving yield for one season as in the case of inorganic fertilisers. Manure is used flexibly over space and time. In the highlands it is applied to the darkua maize field in December to February, to the enset garden from March to August and to root crop fields in September to November. In the lowlands the taro fields substitute for the enset.

The first step of this process is to identify the best site for manuring. This requires careful thought as it is a scarce resource and must be used strategically. Manure is transported to the field by women, and is stored there (usually for a short time), and spread the day before cultivation. This reduces loss of nutrients by leaching and volatilisation. During cultivation the manure is incorporated into the soil to prevent it being washed or blown away. Where cattle are confined to the farm, all manure is captured on the land – in contrast to situations where cattle roam extensively.

Most farmers indicate a shortage of manure as a major constraint. This is due to the reduced number of livestock. Some farmers, especially in the lowlands, have no livestock and therefore no manure. Richer farmers are deterred from loaning animals to poor farmers who cannot afford veterinary medicines, because of the risk that they will not be treated and might die.

Manure is also used for fuel (especially in the highlands, and particularly by those who brew local beverages), which means that less is available for adding to the land. Manure was traditionally reserved for application to the land, but decreased access to wood is forcing farmers to use manure as fuel.

Hoe cultivation

Most farmers hold that hoeing is better for maintaining soil fertility than ploughing. This may be because ploughing turns up less fertile subsoil. Unfortunately this is not an option for large areas of land.

Crop residues

Farmers use crop residues rationally, depending on their situation and the availability of alternatives. The residues have potential for use as fodder, fuel or soil improver. Typically, farmers use teff, barley straw, sweet potato vine and some parts of enset for fodder, and maize stover for fuel. In those areas where fuel and fodder are not scarce (e.g. Fagena Mata), farmers leave some crop residues on the land (e.g. from maize or enset). Fifty per cent of farmers return some crop residues to the soil, particularly resource poor farmers who chop and incorporate straws and stovers. Richer farmers tend to burn residues, or remove them for use as fuel or fodder.

In-situ grazing of livestock

After the removal of grain, straws and stovers at harvest, stubbles remain on the field. Livestock are confined in these fields to graze off the stubbles. This 'in-situ grazing' of stubbles manures the land directly. This practice is more common in the lowlands.

Leaf litter

Some indigenous tree leaves are believed to add fertility to the soil – e.g. mokota (*Cordia africana*), anka, kosua, digsoa, etaa (*Ficus vasta*), bortoia (*Erythrina* species). One-third of farmers use leaf litter as a mulch to enhance soil fertility. However some species of trees are not welcome on the farm, as it is believed that their roots suck nutrients from the soil. Therefore leaves of these species are collected from outside and carried to the farm.

In the highlands, farmers plant hedges of *Erythrina abyssinica* and *Croton macrostachyus* (bisana) around crop fields. Branches are transported to maize and taro fields. The trees also provide timber, fuel, shade and fodder. *Cordia* is planted in coffee gardens to provide light shade and nutrient recycling through leaf fall.

Composting

Composting is advocated by NGOs and was part of the Wolaita Agricultural Research and Development Unit programme, but has not been adopted by many farmers due to labour shortage, termites and lack of knowledge, tools and raw materials. The Ministry of Agriculture has also promoted composting on a food for work basis, in which food is given for the construction of composting pits to Ministry specifications. Farmers have resisted the high

labour involved in some schemes (such as the sophisticated seven-pit system), and prefer the simple, low-labour one-pit system. The major ingredients used for composting are: manure (where available), household refuse, crop residues (except teff straw), tree leaves (especially *Cordia* and *Croton*), grass, and water during dry periods. The manure adds nitrogen, to improve the balance between nitrogen and carbon and thus improve decomposition. It also adds microbes that enhance the decomposition process. Where manure is unavailable, composting can still be done, but decomposition may be slower. The resultant compost may be less rich in nutrients, but still useful to improve soil structure and water-holding capacity.

“Compost making is preparedness against fertiliser shortage and lack of manure. I am very interested in composting as it requires neither cash nor livestock inputs.”

Ato Belachew Balcha

“Compost is so valuable because composted maize resists moisture stress. I should keep my compost in a store, like grain”.

Ato Eyasu Munae, a lowland farmer

Composting technology appears not to move spontaneously from farmer to farmer, although farmers are the best teachers as they have the greatest credibility with other farmers. The role of the Bureau of Agriculture (BoA) in spreading the technology should be that of facilitation and logistical support for bringing farmers together to see and discuss composting. To prepare for this role BoA staff need training in facilitation and the various composting options available.

In Chenchaworeda compost was compared to manure for barley production on farmer's fields over two seasons. The results, given in Table 4, show that the composted plots out-yielded manure over both seasons.

Table 4. Comparison of yields of barley in Chenchaworeda following applications of compost or manure (FARM-Africa, 1999)

Treatment	Yield per ha (quintals)		Average yield q/ha
	Season 1	Season 2	
Compost	12.91	16.94	14.92
Manure	11.70	12.14	11.92

Fallowing

Although the benefits of resting land for one or more seasons are well known, land shortage increasingly limits its application. Sometimes a lack of oxen, or ill health mean that land lies fallow for one year or more. Fallowed land can be invaded by weeds such as *Digitaria*, which are hard to eradicate afterwards, so the advantages and disadvantages of fallowing need to be carefully weighed-up before a decision is made.

Soil conservation

Stone terraces or shallow earth banks (*kella*) are constructed on private lands to reduce the run-off of water that also washes away soil, organic matter and dissolved nutrients. Work parties (comprised of community members who work on a casual basis for food and/or cash payment and assisted by *kella* specialists) are often necessary to establish these stone terraces. Zerua earth bunds are also made at the edge of the farm, while drainage ditches are used to reduce the flow of storm water and mitigate its effects.

Contour ploughing is practiced where soil is susceptible to erosion because of the slope. As all farmers plough land twice, they have to plough up and down the slope, and then across the slope on the same day because it is dangerous to leave the field with vertical furrows in case a storm comes and the water rushes unchecked down the furrow, causing serious erosion.

Effects of Farmer Practice on Nutrient Balances in the Highlands and Lowlands

Highlands

Fertility is maintained in enset gardens, but only by a small margin in the case of resource-poor farmers who tend to remove enset residues, and use less manure. The nutrient balance of highland darkua (homestead) fields is usually negative because so much produce (including crop residue) is harvested and removed from the fields. Farmers should consider returning more residues, and sharing manure more equally between enset and darkua fields. The shoka (outlying) maize fields normally show a negative nutrient balance as the removal of crop products and residues exceeds the nutrients returned. These soils are prone to fertility decline as a result.

Lowlands

Despite a highly positive nutrient balance in lowland darkua plots, yields are not very high, presumably due to other limiting factors. Farmers might be better advised splitting their manure between the high input/low output darkua plots and low input/very low output shoka fields, which are almost all in negative nutrient balance and have a low stock of nutrients which are being unsustainably depleted under present management.

Available Technologies that have Potential to Improve Soil Fertility

Some technologies have been promoted by research and extension agencies in southern Ethiopia, but have not been adopted by farmers for a variety of reasons, including: poor awareness of the technologies, lack of adaptation of the technologies to the needs and resources of farmers, lack of availability of the materials necessary to make the technologies work, lack of convincing demonstration that the technologies provide significant benefits compared to current practice and that they do not incur unacceptable risks.

Four technologies that have been promoted, with rather limited success in southern Ethiopia, are the following:

Alley cropping

This involves alternating strips of crops with bands of leguminous trees or shrubs. The theory is that the leaf-fall and cuttings from the nitrogen-rich leguminous shrubs will fertilise the crop strips and save on expensive fertiliser. If correctly aligned with the contour, the strips are also claimed to have a soil and water conservation function. Alley cropping has not been taken up due to land shortage, lack of extension effort and the divergence of this from current farming practices. However, the overall concept of using nitrogen-rich tree leaves to enhance fertility is a good one, and fits with current practice of using leaf-litter to enhance fertility. A possible way forward is to expand the range of tree species available in local nurseries to include leguminous trees that provide high quality leaf litter.

Rotation with legumes

Farmers understand the concept of using crop rotation to enhance soil fertility. However, the traditional rotation is between cereals and root crops, with few legumes in the system because, under present conditions, their contribution is limited by low pH, low phosphorus levels and pest damage.

Increasing the use of legumes in the system would require an integrated campaign to demonstrate the human nutrition, income-generation and soil fertility enhancement benefits of legumes. To be effective in increasing the quantity of legumes planted this awareness-raising campaign would need to be accompanied by much improved availability of legume seeds, phosphorus fertilisers and (particularly for food legumes) integrated pest management options.

Green manures

In green manuring a bulky, short-duration crop is grown to maximum vegetative growth stage and then ploughed-in so that the vegetative matter decomposes, thereby adding structure and nutrients to the soil. The technique is particularly valuable for light and sandy soils. However, in many locations the acute shortage of land does not allow farmers to allocate land to a green manure crop during the growing season. The technology is therefore only suitable in those

locations where there is some fallowing of land. Even then the technology requires extra labour for land preparation, planting and incorporation, which would deter many smallholder farmers that rely exclusively on family labour.

Cover crops

Cover crops (normally legumes) are planted between the rows of annual or perennial crops to cover the soil surface with a mat of vegetation that reduces erosion, raises organic matter levels in the soil, reduces evaporation from the soil surface and prevents weed growth. In some cases there may be a net transfer of nitrogen from the cover crop to the crop plants. However the cover crop occupies land that could otherwise be used for main crops or intercrops, so that again farmers must decide on the balance of benefits against disadvantages for their particular circumstances.

Implications of Declining Soil Fertility for the Bureau of Agriculture (BoA), the Ethiopian Agricultural Research Organisation (EARO) and Ethiopian Training Institutions

The problem

Approximately 3 million people live in the area of southwest Ethiopia covered by the Farmers' Research Project. Clearing of forests, the removal of crop residues from the fields, land fragmentation, the reduction of fallows, overgrazing, low fertiliser inputs, inadequate soil and water conservation, the cropping of marginal land and poor soil management have all contributed to land degradation. These, however, are the symptoms of four root causes that have led to these actions and have resulted in reduced food security and increased poverty. These include the impoverishment of farmers due to previously heavy taxation and limited support to small-scale farmers; the lack of confidence that farmers have in land as a permanent asset; the increased pressure brought to bear on the land due to increased population, and a reduction in livestock numbers (and therefore manure, which is vital to restoring soil fertility) due to drought, disease, forced sale and lack of feed.

Components of the solution

The Technical Pamphlets from which this publication is drawn emphasise local, low-external-input solutions to the complex problem of soil fertility decline, and particularly encourage effective use of local knowledge and the spread of best farmer practice.

Ethiopian farmers have proved themselves to be very resilient and adaptable to changing circumstances. In this respect, research, extension and training institutions should recognise that:

- Indigenous knowledge is a valuable resource. Understanding that knowledge, and identifying how, when, where, why and by whom it is applied requires the use of sensitive, participatory approaches.

- Existing agricultural practices and indigenous knowledge complement knowledge derived from participatory and conventional research; all sources can be combined to address the problems faced by farmers.
- There is disparity between what farmers know and what they can do (i.e. poverty constrains the application of indigenous knowledge).
- Problems and their solutions vary between location and wealth category. The problems in the lowlands are different to those in the highlands. Solutions designed for resource-rich farmers may not work for farming families with little land or few livestock. Therefore a range of solutions have to be considered, and farmers encouraged to experiment and chose for themselves.
- Solutions designed for the cereal-based farming systems of the northern and central parts of Ethiopia may not work in the root and enset-based systems of Wolaita.

Making better use of farmer's land and soil classifications

Farmers are able to differentiate between soils in their area, and have local names for different soil types. They are aware where each soil type exists, and are able to map the distribution of each soil type within their own Kabele. The characteristics used by farmers are mainly physical properties that directly or indirectly affect the performance and productivity of crops (fertility, erodibility, moisture holding capacity, depth, workability and texture).

Farmer's soil classifications can be used by extension organisations in a variety of ways. They can form part of a common language for communication between farmers and extension staff, allowing extension staff to give recommendations by land type (e.g. the darkua and shoka lands) or by soil type. Farmers can differentiate their land and soil types on the spot, so there is less need for expensive and lengthy soil analysis that requires skilled staff and careful interpretation. Where crops are growing poorly or particularly well, farmers can quickly identify the soil type and its recent management, and link these to performance.

Using their own soil names and local knowledge, farmers can work with extension and research staff to identify suitable locations for demonstrations, on-farm trials, or soil and water conservation interventions. Their land and soil classifications can be used as a framework for understanding the different soil management practices of farmers, leading to the improvement of these practices and the spread of the best practices from one place to another.

Responding to location-specific problems and solutions

There are real differences between highland and lowland soils. Farmers in the highlands maintain that their soil is naturally fertile, but fertility has declined due to continuous cultivation, reduction in fertility inputs and drying of the soil surface. In contrast, lowland farmers say that their soil was of low fertility when they started farming it, but they have built up fertility through intensive ploughing, organic manuring and crop rotation.

This suggests two strategies for intervention by outside agencies. Either each situation has to be fully understood by the outside agency in order to suggest and support appropriate action by farmers, or a range of options can be presented to farmers so that they can choose which best suits their situation.

Looking beyond fertiliser to support the effective use of local materials

Cost, the lack of credit, poor availability and the risk of loss of investment through crop failure due to drought or pests are reasons why farmers don't use fertiliser at the recommended rates. Liberalisation of fertiliser markets has resulted in poor access to fertilisers, especially for remote locations that are unattractive to private-sector merchants. In the medium and longer-terms, access to inputs, and balanced advice on their use as part of integrated soil fertility management should be a priority policy objective. However, for the time being, many farmers cannot afford fertiliser, and soil fertility will have to be tackled using local materials and local knowledge.

Of all the local materials involved in soil fertility management, manure is the most highly valued by farmers. They realise that it is the most important factor in ensuring consistent yields as it brings nitrogen, organic matter and microbial life to the soil. However, nutrient balance trials show that in some cases manure could be more effectively used (especially in the lowlands) by applying a greater proportion to shoka fields, rather than over-manuring darkua fields.

Farmers use crop residues rationally, after weighing up the competing uses of these materials for fuel, fodder and soil improvement. Extension staff tend to ignore the fuel and fodder functions of crop residues. More would be gained by identifying and supporting substitute fuel and fodder sources (such as trees to be planted on farm margins) so that a greater proportion of crop residues could be returned to the soil.

Farmers use tree leaves to add fertility to soils. Species known for their soil improvement qualities should be made easily available to farmers. Decentralised nurseries run by farmers, with support from specialists are an effective way to provide planting materials of species demanded by farmers.

Farmers should be carefully considered when introducing new technology, for example, the seven pit composting method was unpopular because of its high labour input and its complexity. Composting is a technology best spread by practicing farmers to other farmers, demonstrating simple composting methods accepted and used by farmers. However, they need support, and the role of the Bureaus should be that of facilitator, providing logistical and moral support to such activities.

Learning from past experiences

The Wolaita Agricultural Research and Development Unit experience shows that one has to be careful in promoting high external inputs. While a package of inputs can increase yields in the short term, these may not be sustained into the medium term unless organic soil supplements are also applied. This highlights the conflict between the productionists, who wish to use high levels of external inputs to rapidly boost productivity (the Sasekawa Global 2000 approach), and the environmentalists, who pursue sustainable production through better management of natural resources.

Providing security of tenure

Farmers are worried about their security of land tenure. Clear land rights giving continuing access to land is essential for encouraging farmers to invest time and resources in land management.

Keeping up with trends at community level

Farmers are always responding to the changing world around them. The decline in soil productivity continues to produce change at the community level. Recent developments include greater dependence on off-farm employment, social arrangements to bridge resource gaps, changes in crop and tree species and innovations to overcome declining livestock numbers, such as the one-ox plough. Studies such as those conducted by FARM-Africa will continue to be helpful in documenting those changes and suggesting ways in which development agencies can support farmers to overcome new challenges.

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