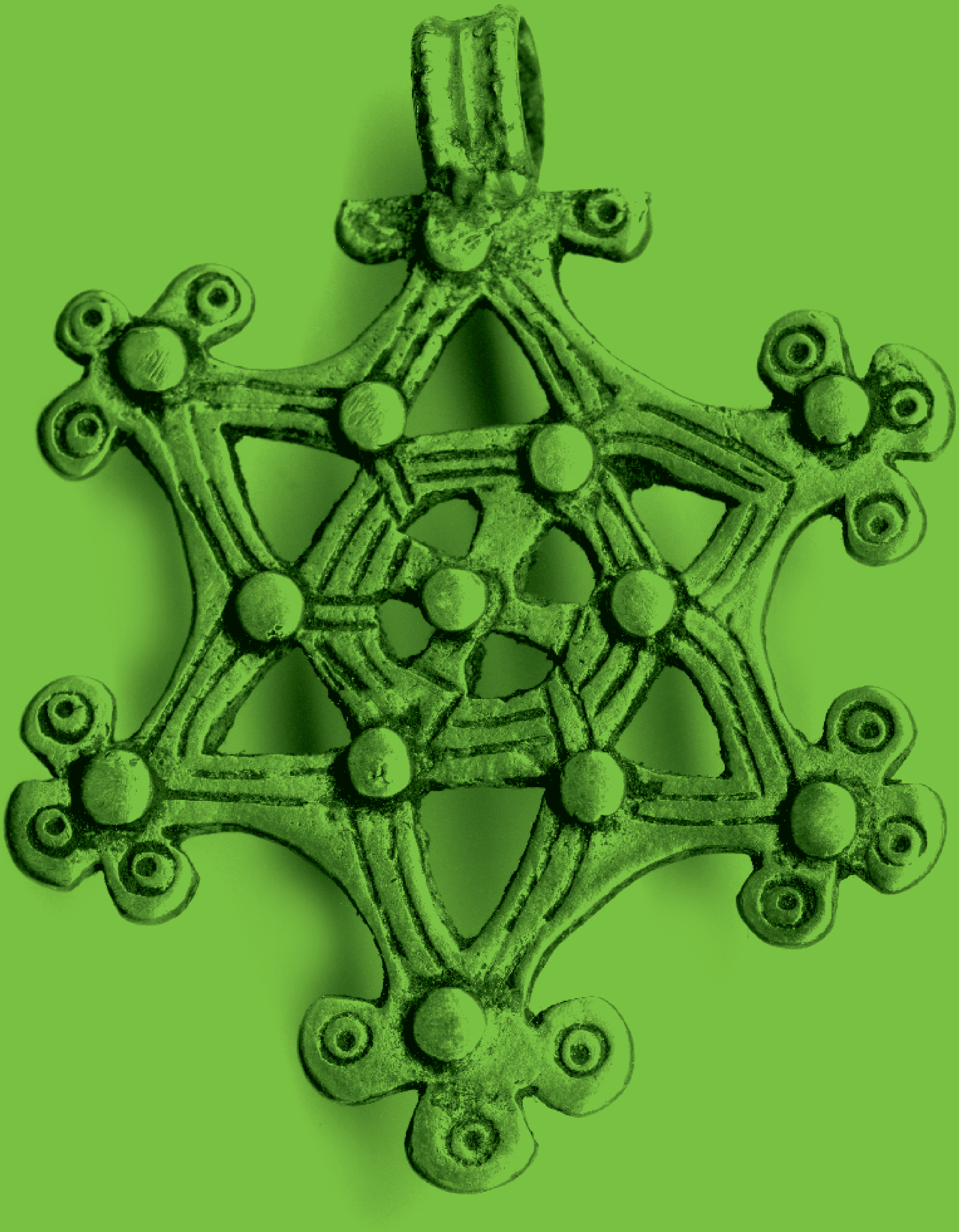

SUCCESSES AND CHALLENGES IN ECOLOGICAL AGRICULTURE: EXPERIENCES FROM TIGRAY, ETHIOPIA

Sue Edwards,
Tewolde Berhan Gebre Egziabher
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CONTENTS

INTRODUCTION 237
Overview of the project 237
Background of the project 237
Challenges for Ethiopia 239
Conditions in Tigray 244
Problems of chemical inputs 246

THE TIGRAY PROJECT 248
Climate change and policy environment for the project 248
Origin and development of the project 251
The impact of compost on crop yields 257
Economic and social impacts of using compost 272
The special needs of women 273
The challenges 276
Farmers' experiences in the project 280

SCALING UP THE TIGRAY PROJECT 283
Institutional ownership 283
Steps in the scaling up process in Tigray 283
Steps in the scaling up process in other parts of Ethiopia 286
Workshops and cross visits 289

CONCLUSION 291

REFERENCES 292

FIGURES

Figure 1: Map of Ethiopia showing the location of Tigray Region 240
Figure 2: Population density of Tigray Region by woreda 245
Figure 3: Barley yields in six communities in 2002 (kg/ha) 259
Figure 4: Maize yields in five communities in 2002 (kg/ha) 260
Figure 5: Teff yields in nine communities in 2002 (kg/ha) 260
Figure 6: Wheat yields in six communities in 2002 (kg/ha) 261
Figure 7: Average grain and straw yields (kg/ha) for seven cereal crops, based on the averages for each crop, Tigray, 2000–2006 268
Figure 8: Average grain expressed as percentage, in grain plus straw yields for seven cereal crops, Tigray, 2000–2006 270
Figure 9: Yields (kg/ha) for faba bean and field pea from Adi Abo Mossa, 1998 and 2002 270
Figure 10: Total recorded crop production in Tigray, 2003–2006 285
Figure 11: Total use of urea and DAP in Tigray, 1998–2005 285

TABLES

Table 1: Grain yields in kg/ha, expenses and returns in ETB for Adi Nifas (2003) 262
Table 2: Grain yields in kg/ha, expenses and returns in ETB for Adi Gua'edad (2003) 263
Table 3: List of local communities from which crop yield data were taken between 2000 and 2006 265
Table 4: List of crops from which yield data were recorded, 2000–2006 266
Table 5: Average yields by treatment in kg/ha for nine crops in Tigray, 2000–2006 267
Table 6: Total biomass and percentage grain by crop in Tigray, 2000–2006 inclusive 269

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EDITORIAL NOTES

The data from the Tigray Project were collected by the woreda agricultural professionals under the supervision of Arefayne Asmelash and Hailu Araya, entered for analysis by Lette Berhan Tesfa Michael, and analysed statistically by Drs Kindeya Gebre Hiwot and Fitsum Hagos of Mekelle University.

ISD is a member of the Third World Network.

INTRODUCTION

Overview of the project

The Tigray Region of Ethiopia is highly degraded, posing difficult challenges to farmers. The degraded environment contributes to low agricultural production, in turn exacerbating rural poverty.

This paper documents the results of an experiment in sustainable development and ecological land management in Tigray. The “Tigray Project”, as it is often referred to, demonstrates that ecological agricultural practices such as composting, water and soil harvesting, and crop diversification to mirror the diversity of soil conditions can bring benefits to poor farmers, particularly to women-headed families. Among the benefits demonstrated are increased yields and productivity of crops, an improved hydrological cycle with raised water tables and permanent springs, improved soil fertility, rehabilitated degraded lands, increased incomes, increased biodiversity, and increased mitigation and adaptation to climate change.

The project is farmer-led, and builds on the local technologies and knowledge of the farming communities. Local communities have been empowered and they now develop legally-recognized bylaws to govern their land and other natural resources management activities.

The successes of the project have led to its expansion to include many more communities in the Tigray Region and in the rest of the country. This happened because the government has now adopted the approach used by the project as its main strategy for combating land degradation and for eradicating poverty from Ethiopia.

Background of the project

Land is degrading fast globally. According to the World Resources Institute (WRI) *et al.* (1998), the Earth’s soil was in 1998 eroding at rates of between 16 and 300 times its rate of formation. Understandably, soil erosion is fastest in mountainous areas and Ethiopia is mountainous. But, this estimate shows that even people in areas that do not look prone to soil erosion should fight land degradation to stop it before it makes their land uninhabitable.

Such an attempt at reversing land degradation in Ethiopia, called “Sustainable Development and Ecological Land Management with Farming Communities in Tigray”, is a broad-based open-ended experiment by farmers and local experts. The main aim of the project is to find out if a community-based ecological approach to rehabilitating the land and improving crop production through the application of ecological principles can both reverse land degradation and improve the livelihoods of poor smallholder farmers. The project motivates local communities to develop their own bylaws to apply ecological principles and to protect their other interests and thus improve the lives of their members. This approach has come to be referred to as the “Tigray Project” because it was started in willing communities in the Tigray Regional State in northern Ethiopia.

Administratively, Ethiopia is divided into nine regional states and two city administrations, below which are zones and then “woredas”, the latter of which can be taken as equivalent to districts. Woredas are made up of parishes called “tabias” in Tigray and “kebeles” in other regions. Each tabia or kebele thus consists of several villages, though the villages are often not clearly delimited since the homesteads are usually scattered over the landscape.

The Tigray Project started in 1996 in four local communities in the central, eastern and southern parts of the Tigray Regional State. In 2009, the Institute for Sustainable Development (ISD) was working with the Bureau of Agriculture and Rural Development (BoARD), woreda experts and development agents to continue implementing the Tigray Project in 45 tabias in 12 woredas in the Tigray Region, in 33 kebeles in Meqdela Woreda in the Amhara Region, in two kebeles in Gimbichu Woreda in the Oromiya Region and in four kebeles in Arba Minch Zuria Woreda in the Southern Nations, Nationalities and Peoples Region. The experience from the Tigray Project is expanding fast in all the crop cultivating parts of Ethiopia. This has been made possible by the inclusion of the practices of the Tigray Project in the extension system of the country thanks to a push by both the Ministry of Agriculture and Rural Development and the Environmental Protection Authority (EPA).

The main activities of the Tigray Project are: training and follow-up on compost making and use including monitoring impacts on crop yields; water and soil conservation activities; restricting free range grazing and feeding animals from cut grass and branches of woody plants; making community ponds, small dams and river diversions to catch and hold water for use in the dry season; promoting and encouraging innovator farmers in water harvesting, bee keeping and use of biopesticides based on indigenous knowledge; supporting women-headed and elderly families (they are the poorest of the poor) through supplying seeds of spices and training in raising fruit and forage tree seedlings for sale to their neighbours; training unemployed girls who complete formal schooling to equip them with skills for earning an income; experience sharing through cross visits; and supporting the use of new and easy to manage technologies such as treadle pumps.

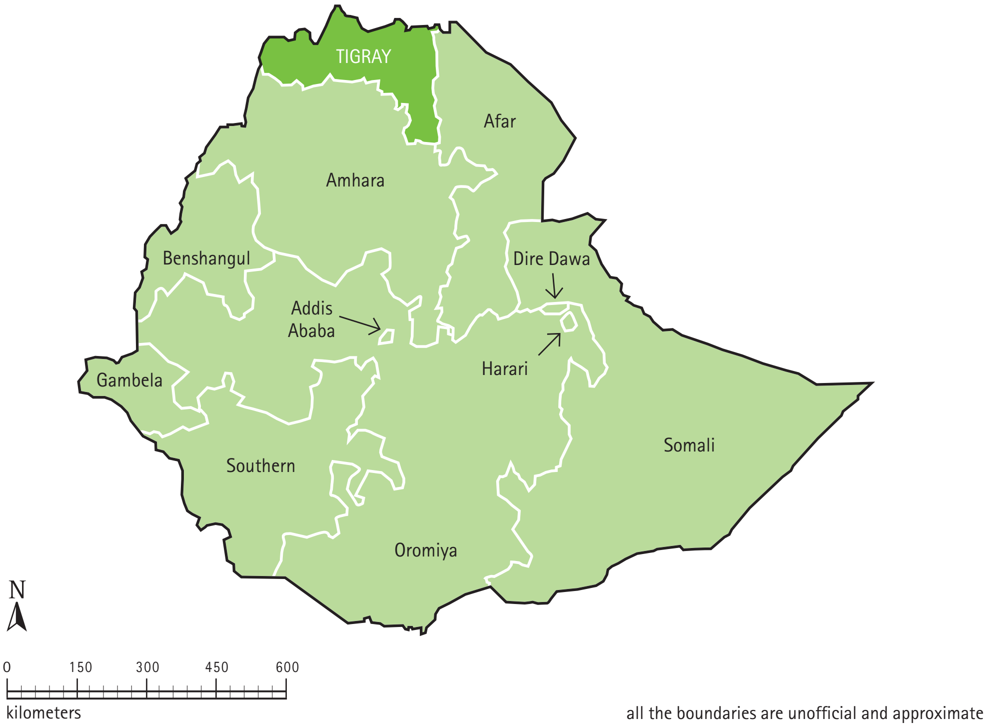
Challenges for Ethiopia

Ethiopia is a land-locked country in the north-east of Africa in what is often referred to as the "Horn of Africa", 32°42'–48°12' east longitude and 3°24'–14°53' north latitude with an area of 1.13 million km^2. Its topography is very diverse, encompassing mountains over 4 000 m above sea level, high plateaus around 2 000 m above sea level, deep and wide gorges cut by rivers and arid lowlands including the Dallol Depression in the north-east, which goes down to 110 m below sea level in the Afar Triangle within the Great African Rift Valley (Figure 1 and EMA, 1988).

The 2007 population and housing census showed the total population of Ethiopia to be 75 million, growing at 2.6 percent a year, of which about 84 percent is rural (FDRE, 2008). More than 49 percent of the population lives in the highlands above 2 200 m altitude, 11 percent lives below 1 400 m and 40 percent in between 1 400 and 2 200 m altitude. Human and animal pressure is higher in the highlands than in the lowlands (Assefa, 2003; EPA, 2003; FAO, 1986).

FIGURE 1

Map of Ethiopia showing the location of Tigray Region



Source: FAO

The south-westerly summer winds are the most important of the country's three moisture-bearing wind systems (FAO, 1986). Originating from the Atlantic Ocean, they bring the greatest amount of moisture during the main rainy season (May/June–August/September). The small rains (February–April) originate from the Indian Ocean and bring rain to the central and eastern highland areas (EMA, 1988; Daniel, 1977). The mean annual rainfall is highest (above 2 700 mm) in the south-western highlands, gradually decreasing to 100 mm or less in the north-eastern lowlands. The mean monthly temperature varies from 45°C (April–September) in the Dallol Depression of the Afar lowlands to less than zero degrees at night in the highlands (November–February) (EPA, 2003; FAO, 1986).

The country currently faces a number of environmental challenges resulting directly or indirectly from human activities, exacerbated by rapid population growth and the consequent increase in the need to exploit the natural resources unsustainably (Asseffa, 2005). Estimates of the annual soil loss range from 400 t/ha in the cultivated highlands to 100 t/ha in the arable lowlands. The total removal is calculated as 1.5–1.9 billion tonnes of topsoil annually with an average total productivity loss from cropland of 1.8 percent (FAO, 1986). The misuse of natural resources caused by need includes burning animal dung as fuel instead of using it as a soil conditioner.

Crop cultivation in Ethiopia has a long history of at least 5 000 years (Clark, 1976), and implements for cutting and grinding seed have been found in stone age sites, such as Melka Konture by the Awash River in central Ethiopia, dating back much earlier. Just when crop cultivation started in Ethiopia has not been determined, but its long history is also reflected in the high agricultural biodiversity, including endemic crops, the best known of which is the cereal, teff (*Eragrostis tef*). The high diversity in crop species and genetic diversity within crops is a reflection of the environmental and cultural diversity of Ethiopia (Engels and Hawkes, 1991).

Many crops that are known to have their centres of origin in the fertile crescent of south-west Asia, for example durum wheat (*Triticum durum*), now have their highest genetic diversity in Ethiopia. The treatment of *Triticum* for the "Flora of Ethiopia and Eritrea" recognizes a highly variable endemic species, *T. aethiopicum*, which is more usually considered as a subspecies or variety of *T. durum* (Phillips, 1995). Other important crops with high genetic diversity in Ethiopia include the cereals – barley (*Hordeum vulgare*), finger millet (*Eleusine coracana*) and sorghum (*Sorghum bicolour*); the pulses – faba bean (*Vicia faba*), field pea (*Pisum sativum* including the endemic var. *abyssinicum*), chick pea (*Cicer arietinum*), lentil (*Lens culinaris*), fenugreek (*Trigonella foenum-graecum*) and grass pea (*Lathyrus sativus*);

the oil crops – linseed (*Linum sativum*), niger seed (*Guizotia abyssinca*), safflower (*Carthamus tinctorius*) and sesame (*Sesamum indicum*); and the root crops – enset (*Ensete ventricosum*), anchote (*Coccinia abyssinica*), "Oromo or Wollaita dinich" (*Plectranthus edulis*), and yams (*Dioscorea* spp.). Over 100 plant species used as crops in Ethiopia have been identified (Edwards, 1991).

European travellers, e.g. Alvares at the beginning of the sixteenth century (Alvares, 1961) and later ones, describe the productivity and health of the highland agriculture – crops, domestic animals and people – and compare this with the depressed situation in much of Europe at that time. Poncet (1967), who visited Ethiopia between 1698 and 1701, described his experience with the words, "no country whatever better peopled nor more fertile than Aethiopia". He described even the mountains he saw as all well cultivated "but all very delightful and covered with trees".

However, since 1974, Ethiopia has been portrayed as a food deficit country with its people and animals suffering from drought and famine. In 2002 around 14 million people (20 percent of the population) required aid as food because of the failure of the rains in much of the eastern parts of the country. In 2008 and early 2009, there was again drought throughout the eastern, south-eastern and southern parts of Ethiopia as well as much of Kenya because of the failure of the rains.

Starting in the second half of the nineteenth century, efforts to build an administratively centralized Ethiopian state as a reaction to European colonialism in other parts of Africa systematically destroyed local community governance because it was suspected that such communities could become possible allies of colonialists. Loss of local governance undermined local natural resource management with loss of protection of woody vegetation, lack of repair of old terraces, and general undermining of any attempts at communal management of natural resources. The feudal landlord system was maintained with the bulk of the population existing as serfs. As Ethiopia entered into the world market, these landlords mined the resources of the peasants with nothing going back to the land. Civil war exacerbated these impacts. The most visible physical impacts have been gully formation eating away the soil with vegetation recovery prevented by free range grazing and the unregulated felling of trees for firewood and other purposes.

There were no inputs in technologies or ideas to help these peasant farmers improve their productivity. They had to continue to rely for their survival on their indigenous knowledge and the rich agricultural biodiversity that they had developed, but were unable to continue effectively developing and using collectively for fear of political reprisal.

Then, in 1974, Emperor Haile Selassie and the feudal system of control over farmers and their land were removed in a revolution that organized the whole population into local, nominally self-governing, organizations with their own elected officials. Under the military government, called the "Derg", there were massive efforts at land rehabilitation through mass mobilization for soil and water conservation, planting of tree seedlings, and the provision of external inputs through cooperatives. However, administration remained centralized and coercive, and overall productivity did not increase. The farmers continued to be ordered about and exploited as had been done under the over-centralized feudal regime. There were also frequent and disruptive redistributions of land. The farmers had no possibility for taking collective decisions on natural resources management and no interest or incentives to invest in improving the land.

In 1991, the military government was overthrown. A new constitution that required decentralization of power and encouraged local community governance was adopted in 1995. In 1993, the Sasakawa-Global 2000 Project was launched to provide high external inputs – principally chemical fertilizer – to farmers.

Although the reasons for poverty are thus complex, those behind the poverty of rural Ethiopia have mainly arisen from total neglect by previous governments, with the land thus being mined to feed an emerging urban population and for trade. These pressures and deliberate interference have led to the collapse of traditional land management systems for maintaining environmental integrity in general and soil fertility in particular. Due to such problems, the total area under food crop production, mainly cereals, has increased while grain production per unit area has remained generally low, less than one tonne a hectare (Assefa, 2003).

The 2004 Human Development Report (UNDP, 2004) classified Ethiopia as one of the least developed countries in the world. Agriculture accounted for more than 75 percent of total exports, over 85 percent of employment, and about 45 percent of the gross domestic product (GDP). Coffee alone made up more than 87 percent of the total agricultural exports. Hides and skins were the next most important export items as raw, processed or manufactured goods (EPA, 2003).

The Government's Sustainable Development and Poverty Reduction Program has identified agriculture as the key sector in which to devote efforts for accelerating socio-economic development and reducing poverty (MoFED, 2002). However, the interventions for agriculture must be ecologically, economically and socially sustainable if the people are to find a way out of poverty that supports improved human welfare and basic rights.

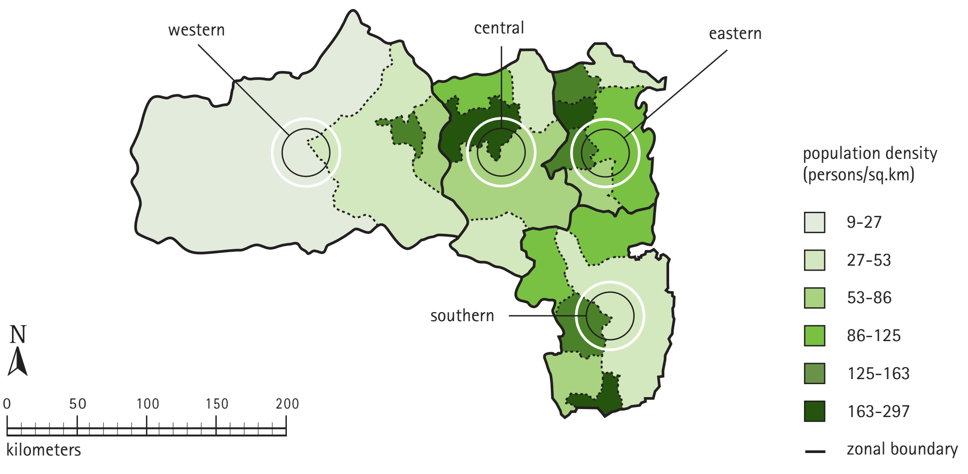
Conditions in Tigray

Tigray Region is found in northern Ethiopia and is generally regarded as the most degraded part of the country. Most of the region is highland, but the eastern part includes the escarpment facing the Great East African Rift Valley. The national population census of 2007 estimated the population of Tigray as 4.3 million with an annual growth rate of 2.5 percent occupying an area of just over 50 thousand square kilometres (FDRE, 2008). The average population density of the region is 80 persons/km^2, with high concentrations in the Eastern, Southern and Central Zones where it is 131, 122 and 115 persons/km^2 respectively (Figure 2 and CSA, 2002).

Average annual rainfall in Tigray is 800–1 000 mm in the west and the highlands of the south dropping to 400 mm in the extreme east. In most parts, it averages between 400 and 600 mm/year (EMA, 1988). The precipitation occurs mostly during a short summer (end of June to mid-September) rainy season, often falling as intense storms (FAO, 1986; Hunting, 1976). Except in some remote areas and around churches, by 1975 the natural dryland forest and woodland vegetation of the Tigray Region had been destroyed. This was because of overgrazing, the progressive increase in demand for fuel wood and land for cultivation. Serious soil erosion and yield reduction have occurred for at least the last 100 years (Hunting, 1976). However, since the 1980s, many areas of natural forest and woodland have reappeared on hillsides following agreements by local communities to restrict access by people and grazing animals to these areas. A study using photographs from Tigray by researchers from the University of Ghent in Belgium and Mekelle University show that much of Tigray now has a better vegetation cover than in 1975, and even than that found in 1868 (Nyssen *et al.*, 2008; Nyssen *et al.*, 2009). However, the recent development of settlements to accommodate landless families, as well as the rise in the urban population continues to put serious pressure on the forest and woodland resources of the region (Hailu and Hailemariam, 2006, unpublished).

FIGURE 2

Population density of Tigray Region by woreda



Problems of chemical inputs

Using chemical fertilizer is recent in Ethiopia. It started in the late 1960s along with the launching of integrated agricultural programmes and projects (EPA, 2003). For millennia, farmers have been using traditional systems of fallowing, crop rotations, manure and wood ash to maintain soil fertility and their crop yields. The Sasakawa-Global 2000 (SG 2000) programme started in 1993 and, in 1995, it was incorporated into the National Extension Intervention Programme of the Ministry of Agriculture. The aim was to boost food crop production through a focused campaign to get farmers to use chemical fertilizer along with high yielding varieties (HYVs), when available, and pesticides. However, the programme mainly gave a strong support to the adoption of diammonium phosphate (DAP) and urea fertilizers through credit schemes and subsidized prices. This was largely because, owing to the diverse nature of the environment, most of the crops had had no HYVs bred, and even those that had been bred, were suited only for limited areas.

Since 1998, the subsidy on chemical fertilizer has been withdrawn while the price has risen. Despite that, by 2001, only around 5 percent of the smallholder farmers of the country, particularly those growing maize and wheat, had become habituated to using chemical fertilizer. But that year, the price dropped out of the bottom of the maize market and the retail price fell to the lowest it had been since 1994/95, well below the cost of production. The retail price in Nekemt (western Ethiopia) in May 2001 was ETB 31 (around USD 4) for 100 kg. This was 41 percent below the market price in the same month in 1995 (Alemu, 2001, unpublished). At the same time, the farm gate price of maize in western Ethiopia as a whole was reported to have fallen to ETB 18 (USD 2.2) for 100 kg.

In 2002, many parts of the country were hit by drought with the result that yields were very low and some crops failed completely; the government requested food aid for nearly 20 percent of the total population. The long-term problem is the large number of rural families facing chronic food insecurity who cannot recover even in a good growing season. Due to the crop failure owing to the drought, many farmers were heavily in debt, and during the growing season of 2003, they withdrew from taking fertilizer especially in areas where moisture stress is frequent. The farmers in these areas say that chemical fertilizer "burns" crops in the field. It also causes soil salinization, damages soil structure, and reduces the number and diversity of smaller organisms living in the soil.

Owing to the unavailability of HYVs, the extension programme allows farmers to select and use the best of their own local varieties. Smallholder farmers use their own saved seed for over 90 percent of the total sowing in the country (Hailu, 2003, unpublished). However, by 2004, the Ethiopian Seed Agency was promoting and distributing seed of higher yielding crop varieties to be grown either for local food processing or for export, and rapid erosion of farmers' varieties was taking place in some of the moister and more accessible areas.

Pesticides are little used except for dealing with the migratory pests, particularly armyworm, desert locust, quelea bird and localized insect swarms, such as Pachnoda beetles on sorghum and the endemic Wello Bush Cricket on cereals. The biggest users of agrochemicals are the few large-scale government-operated farms, particularly those growing cotton. However, smallholder horticultural production from small-scale irrigation systems is expanding and the farmers are making increasing use of chemical inputs. The continuing introduction of HYVs is also attracting pests and chemical control is being made available to farmers. The use of pesticides is often with little or no understanding of either how to store them safely, or how to mix and use them correctly. The misuse of pesticides and fertilizers is damaging human health with severe impacts and even deaths recorded, as well as polluting the surrounding environment (Tadesse and Asferachew, 2008).

Nonetheless, an experiment in sustainable development and ecological land management conducted with farmers in Tigray demonstrates that ecologically sound agricultural practices can succeed and bring benefits to farmers, without recourse to harmful and expensive chemicals (Tewolde Berhan *et al.*, 2004).

THE TIGRAY PROJECT

Climate change and policy environment for the project

The Environmental Policy of the Federal Democratic Republic of Ethiopia had not been approved by the government when the Tigray Project started in 1996, but it was used by the Tigray Project as the basis for identifying technologies that farmers could use. The Environmental Policy emanates from the Constitution of the Federal Democratic Republic of Ethiopia, viz: "All persons have the right to a clean and healthy environment." (Constitution of the Federal Democratic Republic of Ethiopia, Paragraph 1 of Article 44)

The Environmental Policy of the Federal Democratic Republic of Ethiopia was approved in 1997 (FDRE, 1989 EC/1997 GC). Climate change had then not pre-occupied the whole world as it does now, though it was very evident to those involved in examining the global environment. The United Nations Framework Convention on Climate Change (UNFCCC), which was opened for signature in the Rio de Janeiro Conference on Environment and Development in 1992, was already in force in Ethiopia, but the Kyoto Protocol was only just coming into existence. Therefore, the Environmental Policy of Ethiopia does not directly refer to the Kyoto Protocol; neither does it use the now familiar terms of "climate mitigation" and "climate adaptation". However, it deals with the substance of both these terms.

Understandably, the reduction in polluting the atmosphere that the Environmental Policy deals with is limited to attempts at political influence to appeal to the major emitters of greenhouse gases to mend their ways. Article 3.9 (b) states: "To recognize that even at an insignificant level of contribution to atmospheric greenhouse gases, a firm and visible commitment to the principle of containing climate change is essential and to take the appropriate control measures for a moral position from which to deal with the rest of the world in a struggle to bring about its containment by those countries which produce large quantities of greenhouse gases."

Ethiopia's greenhouse gas emissions are limited almost entirely to the relatively few vehicles and aeroplanes that the country runs. The generation of electricity is almost entirely from hydropower. Virtually all household energy is derived from biomass. The firewood and cow dung that are burnt become new firewood and new grass and hence new cow dung during the subsequent rainy season.

Climate adaptation in Ethiopia is, of course, an Ethiopian affair, and the Environmental Policy deals with it in detail. In fact, virtually the whole of the Environmental Policy is directly or indirectly on adaptation to, and simultaneous mitigation of, climate change. For example, Article 3.9 (a) states: "To promote a climate monitoring programme as the country is highly sensitive to climatic variability." Environmental information is treated in more detail in Article 4.7 with its seven sub-articles, and environmental research in Article 4.8 also with its seven sub-articles. The Environmental Policy is found in the website of the EPA at <www.epa.gov.et>.

Ethiopia's commitment to tackling climate change is shown in Article 3.9 (c), which states: "To recognize that Ethiopia's environmental and long-term economic interests and its energy prospect coincide with the need to minimize atmospheric inputs of greenhouse gases as it has a large potential for harnessing hydro-, geothermal and solar energy, none of which produce pollutant gases in significant amounts, and to develop its energy sector accordingly." Article 3.9 (e) states: "To recognize that the continued use of biomass for energy production makes no net contribution to atmospheric pollution as long as at least equal amounts of biomass are produced annually to compensate this and to maximize the standing biomass in the country through a combination of reforestation, agroforestry, the rehabilitation of degraded areas, a general revegetation of the land and the control of free range grazing in the highlands, and to seek financial support for this from industrialized countries for offsetting their carbon dioxide emissions." Article 3.5, with its nine sub-articles, deals with renewable energy in much more detail.

Ethiopia's economy is dominated by the agriculture sector. Even in the future when Ethiopia will have developed strong industrial and service sectors, agriculture will always remain important. Ethiopia has the potential to always continue being suitable for agricultural production to supply the needs of people and other animals.

To adapt agriculture to climate change, and even to continue in a world without any climate change, there will always be a need for good soils, forests and other vegetation cover, genetic resources and water resources. Article 3.1, with its 19 sub-articles, deals with the care that everyone should use to sustainably manage the soils of the country in the unpredictability of floods, droughts and winds that climate change is set to exacerbate. Article 3.2, with its nine sub-articles, covers the management of forests, woodlands and other woody biomass resources so as to maximize wood production for both climate change mitigation and adaptation. Article 3.3, with its 11 sub-articles, shows both the existence in Ethiopia of genetic resources that are of global importance, as well as the management that these genetic resources need for agricultural systems that would be robust now and in the coming future of a changing climate.

Article 3.4, with its ten sub-articles, deals with Ethiopia's plentiful water resources unevenly distributed both geographically and temporally. The Ethiopian mountainous landscape imposes an inherent obstacle to using water resources effectively within the country. It is, on the whole, from the higher and more arid parts along the east that water flows to the lower and more moist parts along the west – i.e. from where it is needed more, to where it is needed less. This paradoxical situation can be alleviated through effective water harvesting and management upstream without compromising Ethiopia's responsibility to maintain the flow of water coming out of its mountainous highlands to its lower-lying neighbouring countries.

The management and use of local resources, including soil, water, vegetation, and agricultural and other forms of biodiversity, can become effective only when the local communities that live in and use each locality are each well informed and effectively organized. Paragraph 4 of Article 50 of the Constitution emphasizes this fact. It states: " ... Adequate power shall be granted to the lowest units of government to enable the People to participate directly in the administration of such units." Article 4.10 of the Environmental Policy, with its nine sub-articles, aims to make environmental information available to local communities. Paragraph (d) of Article 4.5 aims to ensure gender equality in access to environmental information and in empowerment for environmental management. Article 4.2, with its seven sub-articles, aims to empower local communities of men and women that enjoy equal rights and equal access to information on environmental management so that they can organize themselves on equal terms and effectively care for and effectively use their soil, water, vegetation, and biodiversity resources. They would then remain robust and maintain a robust environment to face the vagaries of a changing climate.

How the principles set out in the Environmental Policy are being applied is described in the section on "Scaling up the Tigray Project".

Origin and development of the project

"Is there sufficient biomass to make adequate quantities of compost?" This is the question most often raised whenever there is any suggestion that Ethiopia could use ecological principles to increase crop yield.

In 1995, Dr Tewolde Berhan Gebre Egziabher, then leading the project to develop a Conservation Strategy and Environmental Policy for Ethiopia, was asked by some government officials to design a project that could be promoted among farmers living in degraded areas in order to improve the productivity of their land and rehabilitate their environments while at the same time contributing to carbon sequestration and adapting agriculture to climate change. Some officials in the Tigray Region expressed an interest in the project and a workshop was held in 1995 to launch it and identify local stakeholders.

The project was called "Sustainable Development and Ecological Land Management with Farming Communities in Tigray", though it is usually referred to as 'The Tigray Project'. The local authorities call it the "Sustainable Agriculture/Development Project". The ISD was established to implement it. Activities started in 1996 in partnership with the BoARD and Mekelle University. The direct beneficiaries of the project have been the local farming communities, their local development agents, experts and administrations.

From the beginning, the project has been funded by the Third World Network (TWN), an international NGO network with its head office in Penang, Malaysia. In 2006, TWN published the experiences of the Tigray Project (Hailu and Edwards, 2006), which included preliminary findings from the impacts of the use of compost on yields of crops in farmers' fields.

As from 2005, the Swedish Society for Nature Conservation (SSNC) has also provided funding to ISD for its work in Tigray through supporting the development of a nursery to supply farmers with seedlings of fruit trees and to continue its work with farming communities, local agricultural professionals and their administrations. It has also supported publications, including a poster on making compost to supplement the compost manual in Tigrinya (the local language) published in 2002 (Arefayne, 1994 EC/2002 GC). In 2007, SSNC invited ISD to participate in a study of ecological agriculture based on improving local ecosystem services to identify general patterns in agro-ecosystems that improve production based on local resources and services. The objective of the study is to identify and analyse examples from local agricultural communities in four continents that will be examined with systems ecological and resilience theory as a starting point. The first study visit was to ISD's work with the farmers, farming communities and local agricultural professionals in Tigray. It took place in October–November 2007. The outcome of this study was published in 2008 with the title "Ecological in Ethiopia: Farming with Nature Increases Profitability and Decreases Vulnerability" (SSNC, 2008).

In 2006, the FAO Natural Resources Department provided funding to help ISD compile existing and collect additional yield data to produce a database of over 900 crop yield records from farmers' fields, and pay for entry into a computer and statistical analysis of the data (Edwards *et al*, 2007). The results of this analysis are presented in the next section.

The first four communities to become involved in the project in 1996 were Adi Nifas in the densely populated Central Zone west of the ancient town of Axum, Adi Abo Mossa in the Southern Zone on the sloping land beside Lake Hashenge, and Gu'emse and Ziban Sas in the Eastern Zone, generally regarded as the driest and most degraded part of the region. The work started with an experienced senior extension officer of the BoARD, Arefayne Asmelash, consulting the communities about the problems with their environment, and discussing possible solutions, none of which required high external inputs but demanded commitment from the community members and local agricultural professionals.

The suggested technologies (basket of choices) were designed to build on the respective local community's own traditional systems of farming and land management with some selected additions from field-tested traditional and scientific knowledge gleaned from within Ethiopia and other countries.

The farmers were thus stimulated to select from a 'basket of choices' made up from suggestions put forward by ISD, BoARD and the farmers themselves. The key components of the project were as follows:

- Making and using compost to restore soil fertility, to sequester carbon and to avoid getting into a debt trap by buying chemical fertilizer on credit;
- Restricting free range grazing by domestic animals and encouraging cutting and carrying of fodder to feed them, in order for the natural vegetation to recover and biodiversity to be protected;
- Digging trench bunds for catching both water and soil along field boundaries;
- Halting and rehabilitating gullies through building check dams at regular intervals;
- Terracing slopes both to minimize soil erosion and to maximize rain water infiltration;
- Making ponds to store rain water for animals and for making compost in the dry season;
- Planting small multipurpose trees – particularly *Sesbania sesban* – local grasses and legumes on the bunds; and
- Formulating and using bylaws to coordinate the activities of the members of the local community and thus to control access to and use of local biological resources including the restrictions of free range grazing by domestic animals.

Each of the four original communities chose a different entry point into the project.

Adi Nifas had two gullies eating away the farmers' fields and the farmers agreed to try the other components in the project if the gullies could be stopped. Check dams were built by the community at intervals in the gullies, which successfully arrested further development of the gullies; Adi Nifas became the model community demonstrating how all the components reinforced each other to improve the lifestyles of the farmers. By 2001, a spring and small stream that had dried up for decades reappeared and farmers below the project site started a small irrigation scheme because of the water flow that enabled them to harvest at least two crops a year.

Ziban Sas had had its grazing area of 13.5 ha destroyed by sheet erosion, and the water table had dropped to below 12 m. Therefore, the farmers, particularly the women, focused first on rehabilitating their grazing land, and then became interested in the other components. With grazing animals kept off the land, the local grasses and other herbs soon reappeared, and check dams and trench bunds led to better infiltration of water. But of more significance for the women was the raising of the water table so that they were able to use their local well again.

Gu'emse also had a very large gully created by powerful flooding in the rains from a large catchment area. This was eating away the farmers' fields and bringing deposits of silt onto their land. Attempts to control this gully were not successful until 2005 when appropriate materials and expertise were made available to the community. The initial failure to check the gully somewhat discouraged the farmers although a core of about 45 households continued making and using compost and also initiated making a communal pond to catch the flood water. Reclaiming the large gully required inputs of cement and wire-mesh, locally called "gabion", to hold the stones in place and the success has reversed the community's attitude to the project. The protection of their achievements features prominently in their bylaws and they have planted many trees and grasses to help stabilize both the catchment area and the gully.

Adi Abo Mossa is a relatively well-endowed area with good rainfall and a large grazing area around the lake. The farmers had been using increasing amounts of chemical fertilizer. Therefore, the implementers of the project wanted to encourage the farmers to adopt composting in order to reduce the threat of eutrophication in Lake Hashenge. The farmers make very good quality compost in large quantities and most have been able to give up using chemical fertilizer. But this is the only component of the project adopted by these farmers. This is because neither increasing biomass through restricting free range grazing, nor raising the water table are important to them.

In all four communities, the farmers quickly saw in one or two growing seasons the impact of compost on crop yields and the improved water holding capacity of the soil in their fields. In May 1998, representatives of the farmers and their development agents from the four communities made cross visits to each others' areas ending up with a two-day discussion and general evaluation of what they had seen of the project's activities. This encouraged all the communities, except those in Adi Abo Mossa, to take up all the components of the project.

These activities have increased the biomass in the farms and their surroundings. Therefore, policy makers have come to realize that the answer to the question "Is there sufficient biomass to make adequate compost?" is "if farmers want, they can make enough compost, especially at the end of the growing season".

In 2001, the Ethiopian government issued its Policy on Rural Development Strategies and Guidelines (MoI, 2001) and set up a supra-ministry, the Ministry of Agriculture and Rural Development, to coordinate activities for its implementation. The policy regards environmental rehabilitation as an essential precondition for increasing productivity. It emphasizes the need to improve local marketing infrastructure, and also to develop more agricultural products so as to diversify the economic base of the country.

The Environmental Policy of Ethiopia has incorporated a basic principle similar to one adopted in organic agriculture: "to ensure that essential ecological processes and life support systems are sustained, biological diversity is preserved and renewable natural resources are used in such a way that their regenerative and productive capabilities are maintained, and, where possible, enhanced...; where this capacity is already impaired to seek through appropriate interventions a restoration of that capability" (FDRE, 1989 EC/1997 GC). This policy supports the development of more specific policy and regulations for organic agriculture; the government has already issued an "Ethiopian Organic Agriculture System" (FDRE, 2006).

There is an increasing awareness of the importance of producing healthy fruits and vegetables organically for the expanding educated middle-class and expatriate market in Addis Ababa. For example, Genesis Farm started in 2001 and its organic production now covers over 40 hectares. The farm combines dairy and poultry production together with growing vegetables, fruits and ornamental plants. It sells certified products on the export market. However, there is also a fast expanding local market and it is interesting to note that none of the items sold by Genesis are more expensive than other locally produced items, and several are even cheaper. Local workers are able to buy their vegetables from the farm shop. There are now several other farms and urban agriculture associations within and in the peri-urban area of Addis Ababa that are supplying ecologically produced healthy fruits and vegetables to local shops and restaurants.

The international trade in organic products is an expanding niche market that Ethiopia is geographically well situated to exploit. Communities in the southern and south-western parts of the country have formed cooperative societies and unions growing and exporting Arabica coffee with an organic and fair trade label. This has enabled farmers to obtain prices similar to those in 1996, when the international coffee prices started to collapse. A survey in 2008 found that Ethiopia had 137 822 ha of land certified as organic being used by 110 861 farmers mostly organized in 40 companies and cooperative unions, with a few in individual farms. There were four foreign, but no national, certifying organizations working in Ethiopia.

In 2005, the Ministry of Agriculture and Rural Development produced a "Guideline on Community-based Participatory Watershed Development" together with an Annex. These are comprehensive documents incorporating the experience of many practitioners. Participation is seen as central to the planning, implementation, monitoring and evaluation of watershed development. The documents include information cards on the technologies that can be used, including one for compost making. Although ISD is not mentioned specifically, its experience in Tigray has helped in shaping the development of this document.

In 2006, environmental issues were incorporated into the revised second phase of Ethiopia's Poverty Reduction Strategy Programme (PRSP). The PRSP is taken as the guideline for all development support by the donor community in Ethiopia. One of the biggest programmes that has been launched by the government is the "Productive Safety-Net Programme", which is channelling funds directly to woredas for use in public works activities as well as in environmental rehabilitation focusing on watersheds.

The impact of compost on crop yields

The first exercise in getting yield data from the use of compost was in 1998. The data showed that using compost gave similar yield increases as the use of chemical fertilizer. In November 2001, these results were presented at a workshop in Axum including representatives from all the regions as well as key government offices in Addis Ababa. The data were published as an annex to the booklet, "Natural Fertilizer" (Edwards, 2003). ISD was urged by the senior staff of the BoARD to continue monitoring the impact of compost on crop yields, and this has been done each year since 2000 in some of the local communities with which ISD has been working.

The method used to obtain the yield data is based on the crop sampling system of the FAO. The fields for taking the yield samples are selected together with the farmers and are chosen to represent the most widely grown crops. Three one-metre square plots are harvested from the field. These plots are placed in the field to reflect the range of conditions of the crop, i.e. both well grown and not so well grown areas are selected from the centre and towards the edge of the field. The harvested crop is then threshed and the grain and straw are weighed separately. The plot data are recorded along with the name of the farmer, the crop and the treatment as well as the location and the date. The farmer keeps the straw and grain. The straw is important because it is the main animal feed, especially during the dry season.

The average from several fields of the same crop in the same area given the same treatment is calculated. "Check" means the field received no treatment, although it may have received compost in one or more of the previous years. "Compost" is for fields treated with mature compost. The rates of compost application range from around 3.5 t/ha in poorly endowed areas, such as the dry Eastern Zone of the region (Ziban Sas and Gu'emse), to around 15 t/ha in the moister Southern Zone (Adi Abo Mossa). "Chemical fertilizer" is for fields treated with diammonium phosphate (DAP) and urea. The recommended rates are 100 kg/ha of DAP, and 50 kg/ha of urea.

The yields are converted to kg/ha for comparison. It should, however, be remembered that farmers' fields are very small, often less than a quarter of a hectare, and that the total cultivated area of most farmers is less than one hectare.

An important feature of the Tigray Project is that it is to a large extent led by the farmers. They choose which crops to treat with compost and which with chemical fertilizer – some also compare the use of manure, while a few combine compost and chemical fertilizer.

Crop yields in 2002

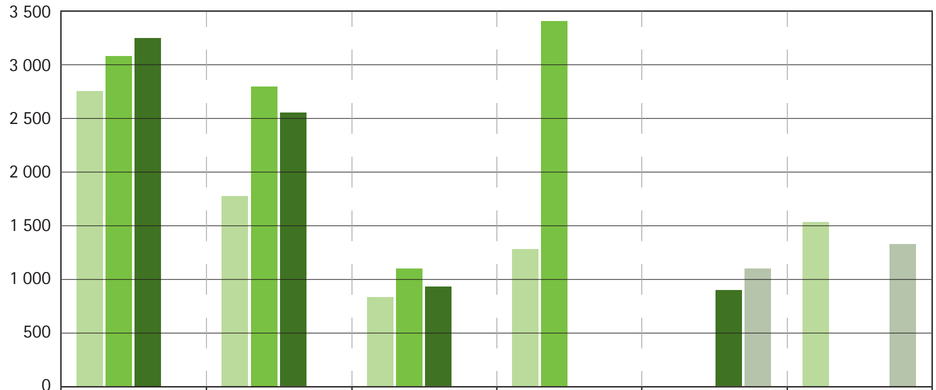
The year 2002 had poor rainfall in most parts of Tigray and only a few farmers got grain from their fields. However, it was a very good demonstration of the effect of compost on the moisture holding capacity of the soil. The drought was very severe, even in western Tigray, but a farmer in Adi Aw'ala applied compost to his field of sorghum and got a grain yield equivalent to 2 t/ha and a straw yield of 3 t/ha; an untreated field gave only the equivalent of 0.8 t/ha of grain and 1.5 t/ha of straw. He also grew maize with compost doubling the yield of the check (see Figure 4).

Figures 3–6 give the yields for barley, maize, teff and wheat from 14 communities. Only four of the communities, Adi Abo Mossa, Adi Gua'edad, Adi Nifas and Gergera, had yields from three of the four crops. Teff is the fastest maturing of the crops, and yields were obtained from nine of the communities, the best being 3.9 t/ha from a chemically treated crop in Enda Maino, where the compost treatment gave 2.9 t/ha. But, overall, the fields that had received compost gave higher yields than those treated with chemical fertilizers.

It is interesting to see that the yields from the checks in Adi Abo Mossa and Adi Nifas were close to those from the fields that had received compost or chemical fertilizers. These two communities had been making and using compost since 1996, and its residual effect in the soil is thus clearly seen. The very low yields for all crops in Adi Nifas in 2002 are the result of the drought. More normal yields are given in Table 2.

FIGURE 3

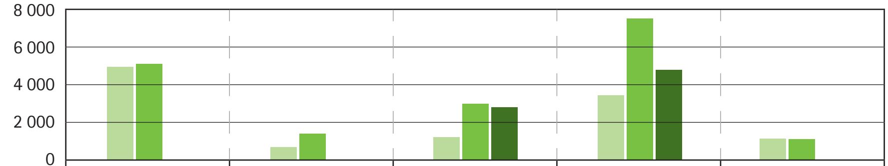
Barley yields in six communities in 2002 (kg/ha)



	ADI ABO MOSSA	ADI GUA'EDAD	ADI NIFAS	GERGERA	ZIBAN SAS	GU'EMSE
check	2 765	1 782	833	1 283	-	1 535
compost	3 090	2 808	1 100	3 420	-	-
chemical fertilizer	3 263	2 562	933	-	900	-
manure	-	-	-	-	1 100	1 333

FIGURE 4

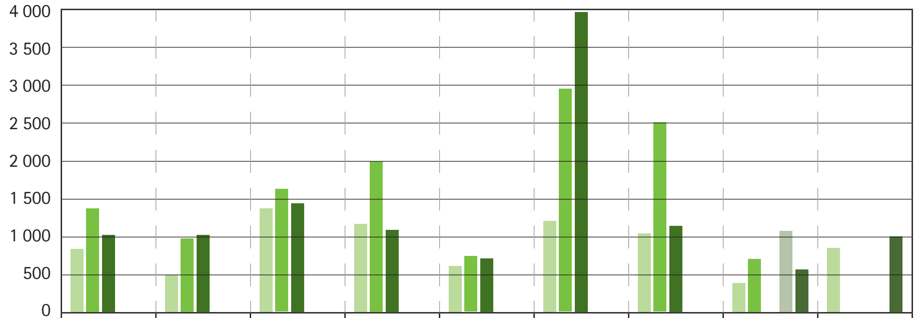
Maize yields in five communities in 2002 (kg/ha)



	ADI ABO MOSSA	ADI AW'ALA	GURORO	KENEF	ADI NiFAS
check	4 948	700	1 218	3 460	1 150
compost	5 130	1 416	2 994	7 583	1 136
chemical fertilizer	-	-	2 830	4 800	-

FIGURE 5

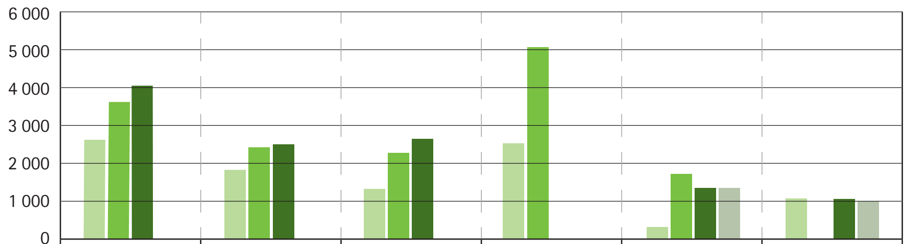
Teff yields in nine communities in 2002 (kg/ha)



	SELAM BIKALSI	GURORO	ADI GUA'EDAD	KENEF	ADI NiFAS	ENDA MAINO	GERGERA	SHERAFO	ADIBO GULJI
check	829	486	1 365	1 160	605	1 201	1 033	383	842
compost	1 364	966	1 620	1 986	734	2 943	2 500	700	-
chemical fertilizer	1 015	1 016	1 432	1 083	706	3 960	1 133	-	-
dung + compost	-	-	-	-	-	-	-	1 067	-
dung	-	-	-	-	-	-	-	558	995

FIGURE 6

Wheat yields in six communities in 2002 (kg/ha)



	ADI ABO MOSSA	ADI GUA'EDAD	ENDA MAINO	GERGERA	ZIBAN SAS	GU'EMSE
check	2 783	1 882	1 333	2 716	400	1 113
compost	3 820	2 402	2 376	5 083	1 800	-
chemical fertilizer	4 030	2 522	2 783	-	1 450	1 110
dung	-	-	-	-	1 500	925

Crop yields in 2003/4

The rainy season was better in 2003 and yields were generally higher than in 2002. In spite of the differences on them of the impact of the failure of the rains in 2002, as can be seen from Figures 3 and 5, the communities of Adi Nifas and Adi Gua'edad are geographically close to each other and it was considered useful to compare the use of compost and chemical fertilizer by the two communities, and also to give an indication of the value of the crops as well as the expense of using chemical fertilizer for the farmers. In 2003, 100 kg of DAP was ETB 270, and 50 kg of urea was ETB 107. Thus the total cost for applying these to one hectare in 2003 was ETB 377 as cash or ETB 433.55 through credit including 15 percent interest.

Average grain prices in ETB per 100 kg in the local market in 2003 in Tigray were 225 for teff, 155 for maize, 200 for faba bean, 170 for barley, 170 for wheat, and 145 for finger millet. The averages were calculated from prices collected from different markets in the region.

It can be argued that the opportunity cost for making compost should also be included. However, it should be noted that compost is made when there is little need for other farm activities, i.e. during the gap between crops flowering and maturing for harvest, and the opportunities for off-farm work are not high at this time. All the materials for making compost are freely available locally. Therefore, the net income does reflect what the farmer can expect to get from his/her crops.

The Adi Nifas farmers had been using compost for seven years while those of Adi Gua'edad had only used compost for two years. The yields are shown in Tables 1 and 2.

TABLE 1

Grain yields in kg/ha, expenses and returns in ETB for Adi Nifas (2003)*

CROP	INPUT	YIELD	GROSS INCOME	FERTILIZER COST	NET INCOME
Faba bean	**Compost**	**4 391**	**13 173**	**-**	**13 173**
	Check	2 287	6 861	-	6 861
Finger millet	**Compost**	**2 650**	**4 505**	**-**	**4 505**
	Check	833	1 416	-	1 416
Maize	**Compost**	**5 480**	**8 768**	**-**	**8 768**
	Check	708	1 133	-	1 133
Teff	**Compost**	**1 384**	**3 875**	**-**	**3 875**
	Chemical fertilizer	1 033	2 892	377	2 515
	Check	739	2 069	-	2 069
Wheat	**Compost**	**2 250**	**5 625**	**-**	**5 625**
	Chemical fertilizer	1 480	3 700	377	3 323
	Check	842	2 105	-	2 105
Barley	**Compost**	**1 633**	**3 266**	**-**	**3 266**
	Check	859	1 718	-	1 718

*In 2003, 10 ETB = 1 Euro, or 8.5 ETB = 1 USD

In Adi Nifas only one farmer used chemical fertilizer for his teff, and the yield was less than what he got from his field with compost. But in Adi Gua'edad, all the farmers used chemical fertilizer, even on their faba bean. However, the yield of the faba bean was less than half of the yield from using compost, and the economic return from applying the compost was much higher.

TABLE 2

Grain yields in kg/ha, expenses and returns in ETB for Adi Gua'edad (2003)*

CROP	INPUT	YIELD	GROSS INCOME	FERTILIZER COST	NET INCOME
Faba bean	**Compost**	**2 900**	**8 700**	**-**	**8 700**
	Chemical fertilizer	1 100	3 300	377	2 923
	Check	766	2 298	-	2 298
Finger millet	**Compost**	**2 000**	**3 400**	**-**	**3 400**
	Chemical fertilizer	1 433	2 436	377	2 059
	Check	500	850	-	850
Maize	**Compost**	**2 000**	**3 200**	**-**	**3 200**
	Chemical fertilizer	1 133	1 813	377	1 436
	Check	680	1 088	-	1 088
Barley	**Compost**	**2 193**	**4 386**	**-**	**4 386**
	Chemical fertilizer	1 283	2 566	377	2 189
	Check	900	1 800	-	1 800
Wheat	**Compost**	**1 020**	**2 550**	**-**	**2 550**
	Chemical fertilizer	1 617	4 043	377	3 666
	Check	590	1 475	-	1 475
Teff	**Compost**	**1 650**	**4 620**	**-**	**4 620**
	Chemical fertilizer	1 150	3 220	377	2 843
	Check	390	1 092	-	1 092

*In 2003, 10 ETB = 1 Euro, or 8.5 ETB = 1 USD

These results from the two communities are a reflection of what has happened in all the areas where the farmers have learnt how to make and apply compost. In the first year or two, they continue to use chemical fertilizer, but as they gain confidence in making compost and also see its residual effects in restoring soil fertility, they stop buying chemical fertilizer. It is interesting to note that after farmers stop using chemical fertilizer, no reduction in yield has been recorded as they 'convert' to using only compost. This is probably because the use of chemical fertilizer is relatively recent, i.e. only since 1995 or even later. More importantly, this is probably because they do not plant the so-called high yielding varieties, which have a high demand for chemical fertilizer. Instead, they plant their best yielding traditional varieties, which have been bred to thrive in organically fertilized fields.

Statistical analysis of crop yields sampled between 2000 and 2006

Starting from 2000, yields have been taken from plots in farmers' fields in 19 communities in eight of the 53 woredas of Tigray Region (Table 3). The majority of the communities (17) are found in the drought prone areas: Alamata of the Southern (two communities), and all parts of the Eastern (six communities) and Central (nine communities) Zones. The soils of these areas are generally prone to land degradation and the rainfall is erratic. However, two communities are found in better endowed areas: Adi Abo Mossa on the land sloping down to the shores of Lake Hashenge of Southern Tigray, where the soils are deep, rainfall more reliable and some farmers have larger cultivated areas and large herds of cattle, and Adi Aw'ala in Western Tigray where the rainy season is generally two to four weeks longer than in the rest of the region.

Between 2000 and 2006, grain and straw yield data were taken separately from 974 plots. The names of the 11 crops from which observations were recorded are given in Table 4. But four of these were dropped from the final statistical analysis because each had less than ten observations. This left seven cereal and two pulse crops in the final statistical analysis.

TABLE 3

List of local communities from which crop yield data were taken between 2000 and 2006

<table>
<tr><th>ZONE</th><th>WOREDA</th><th>TABIA</th><th>COMMUNITY</th></tr>
<tr><td rowspan="2">Southern Tigray</td><td>Ofla</td><td>Hashenge</td><td>Adi Abo Mossa (O)</td></tr>
<tr><td>Alamata</td><td>Lemat
Seelam Beqalsei</td><td>Adi Abo Golgi
Seelam Beqalsei</td></tr>
<tr><td rowspan="3">Eastern Tigray</td><td>Sa'esi'e Tsada Amba</td><td>Sendeda
Mai Megelta
Agamat</td><td>Tsebela
Zeban Sas (O)
Gu'emse (O)</td></tr>
<tr><td>Kilte Awla'elo</td><td>Mai Weyni</td><td>Sherafo</td></tr>
<tr><td>Atsbi-Wonberta</td><td>Hayelom</td><td>Gergera
Enda Maino</td></tr>
<tr><td rowspan="8">Central Tigray</td><td rowspan="7">Tahtai Maichew</td><td>Mai Berazio</td><td>Adi Nifas (O)</td></tr>
<tr><td>Akab Se'at</td><td>Adi Gua'edad</td></tr>
<tr><td>Ruba Shewit</td><td>Adeke Haftu</td></tr>
<tr><td>Mai Siye</td><td>Mai Tsa'ida</td></tr>
<tr><td>Kewanit</td><td>Hagere Selam</td></tr>
<tr><td>Adi Guara</td><td>Tselielo</td></tr>
<tr><td>Adi Hutsa</td><td>Kenef</td></tr>
<tr><td>Kolla Tembien</td><td>Guroro
Miwtsa'e Worki</td><td>Shimarwa
Adi Reiso</td></tr>
<tr><td>Western Tigray</td><td>Tahitay Adyabo</td><td>Adi Aw'ala</td><td>Adi Aw'ala</td></tr>
<tr><td>Total</td><td>8</td><td>18</td><td>19</td></tr>
</table>

Key – (O) refers to communities where work started in 1996/7, the others joined the project later.

The data were analysed using the statistical program, STATA. The average grain and straw yields converted from g/plot to kg/ha for each treatment for the nine crops are given in Table 5. The table also gives the number of observations included in the analysis for each crop and treatment. The average of the grain and straw yields for each treatment for the seven cereal crops is shown in Figure 7.

The data for the nine crops were subjected to linear regression analysis by treatment based on the values obtained from fields where compost was applied, chemical fertilizer (DAP and urea) was applied and no input (check) was applied. The null hypothesis used was that the treatments have no impact on the yields.

TABLE 4

List of crops from which yield data were recorded, 2000–2006

	CROP	SCIENTIFIC NAME	REMARKS
1	Barley	Hordeum vulgare	Many farmers' varieties are grown
2	Durum wheat	Triticum durum	The most widely grown wheat
3	Finger millet	Eleusine coracana	Not grown as widely as in the past
4	Hanfets	Hordeum vulgare + Triticum durum	A mixture of barley and durum wheat grown in areas prone to erratic rainfall and generally poor soils
5	Maize	Zea mays	Grown more for the fresh cobs than the grain
6	Millet	Eleusine coracana	The same as finger millet – less than ten observations were recorded under this name
7	Sorghum	Sorghum bicolor	Grown more widely in the western lowlands than the highlands
8	Teff	Eragrostis tef	Ethiopia's endemic cereal with many varieties
9	Chick pea	Cicer arietinum	Not very widely grown – less than ten observation were recorded
10	Faba bean	Vicia faba	The most widely grown pulse, also known as horse bean
11	Field pea	Pisum sativum	More often grown mixed with faba bean than by itself
12	Haricot bean	Phaseolus vulgaris	A recent introduction by the BoARD – less than ten observation were recorded
13	Horse bean	Vicia faba	The same as faba bean – less than ten observations were recorded under this name

The probability that this null hypothesis could explain the results was found to be less than 0.05. In other words, the confidence limit was found to be above 95 percent. The increase in grain yields in fields where chemical fertilizer was applied was significantly higher (95 percent confidence limit) than in the fields where no input (check) was applied, and the increase in the grain yields in fields where compost was applied was also significantly higher (95 percent confidence limit) than in the fields where chemical fertilizer was applied. The significance in the differences among the straw yields for each treatment was similar. The differences among treatments in the yields of each of the crops were also similarly significant.

TABLE 5

Average yields by treatment in kg/ha for nine crops in Tigray, 2000–2006

CROP TYPE	AVERAGE YIELD (KG/HA)					
	CHECK		COMPOST		FERTILIZER	
	Grain	Straw	Grain	Straw	Grain	Straw
Barley	1 115	2 478	2 349	4 456	1 861	3 739
	(n=56)	(n=52)	(n=57)	(n=55)	(n=36)	(n=35)
Durum wheat	1 228	2 342	2 494	3 823	1 692	3 413
	(n=73)	(n=67)	(n=61)	(n=57)	(n=48)	(n=45)
Finger millet	1 142	2 242	2 652	4 748	1 848	3 839
	(n=16)	(n=16)	(n=14)	(n=13)	(n=8)	(n=7)
Hanfets	858	2 235	1 341	3 396	1 199	2 237
	(n=31)	(n=31)	(n=31)	(n=31)	(n=29)	(n=29)
Maize	1 760	3 531	3 748	4 957	2 900	3 858
	(n=31)	(n=20)	(n=41)	(n=31)	(n=25)	(n=13)
Sorghum	1 338	2 446	2 497	3 662	2 480	4 433
	(n=14)	(n=13)	(n=11)	(n=10)	(n=5)	(n=5)
Teff	1 151	2 471	2 143	3 801	1 683	3 515
	(n=106)	(n=94)	(n=75)	(n=66)	(n=71)	(n=68)
Faba bean	1 378	2 121	2 857	4 158	2 696	3 783
	(n=20)	(n=17)	(n=23)	(n=24)	(n=3)	(n=3)
Field pea	1 527	1 201	1 964	1 625	0	0
	(n=9)	(n=9)	(n=9)	(n=9)		

'Hanfets' is a mixture of barley and durum wheat
n = Number of records for each treatment and crop

The use of compost also gave higher yields than the use of chemical fertilizer, though differences in the yields from compost and from chemical fertilizer were not as great as the differences between the use of compost and the check. For sorghum and faba bean, the yields from the use of compost and chemical fertilizer were similar. But the yield difference for all the other crops was greater with that from the compost treatment being always higher than that from the use of chemical fertilizer.

FIGURE 7

Average grain and straw yields (kg/ha) for seven cereal crops, based on the averages for each crop, Tigray, 2000-2006

	NO INPUT (S=393/G=327)	COMPOST (S=263/G=290)	CHEMICAL FERTILIZER (S=202/G=222)
grain	1 200	2 473	1 812
straw	2 477	4 073	3 404

s=number of observations for straw yield
g=number of observations for grain yield

The proportion, expressed in percentages, of the grain in the total harvested biomass (grain + straw) for each of the nine crops is given in Table 6. For the cereal crops, the percentages of the grain in the harvest are given in Figure 8. The data are only indicative because the farmers usually leave long stubble up to 20 cm tall from their cereal crops in the field for domestic animals to graze on. For faba bean and field pea, however, all the above ground biomass is harvested. The results show that compost not only increases the overall biomass yield, but also increases the proportion of the grain to straw in the yield. The most striking crop is field pea where the proportion of grain in the total yield exceeded 50 percent for both the check and the compost treatment, but the field pea 'check' was probably grown in fields that had received compost in previous years – see Figure 9 and the discussion on it. For all the other crops, the proportion of grain in the total harvested yield ranged from 28 percent for hanfets to 35 percent for sorghum in check fields,

TABLE 6

Total biomass and percentage grain by crop in Tigray, 2000–2006 inclusive

	% GRAIN IN TOTAL BIOMASS YIELD (KG/HA)					
CROP TYPE	CHECK		COMPOST		FERTILIZER	
	% grain	total	% grain	total	% grain	total
Barley	31	3 593	35	6 805	33	5 600
Durum wheat	34	3 570	39	6 317	33	5 105
Finger millet	34	3 384	36	7 400	32	5 687
Hanfets	28	3 093	28	4 737	35	3 436
Maize	33	5 291	43	8 705	43	6 758
Sorghum	35	3 784	41	6 159	36	6 913
Teff	32	3 622	36	5 944	32	5 198
Faba bean	39	3 499	41	7 015	42	6 479
Field pea	56	2 728	55	3 589	0	0

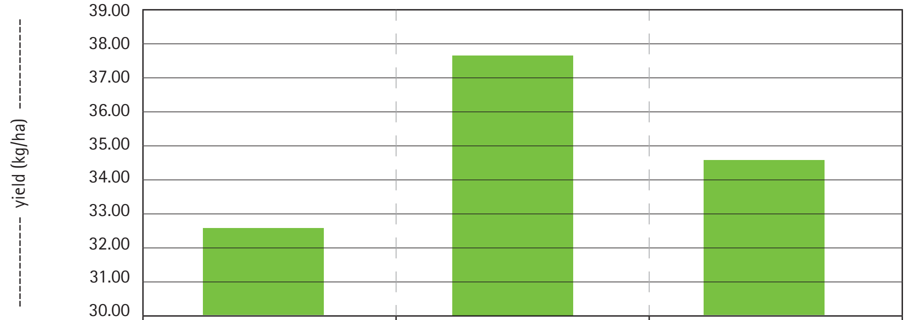
"Hanfets" is a mixture of barley and durum wheat

from 28 percent for hanfets to 43 percent for maize in fields treated with compost, and from 32 percent for finger millet and teff to 43 percent for maize in fields where chemical fertilizer had been applied.

In 1998, when the first set of data were collected from plots in the four original communities, the grain yields of the cereals from the fields without any inputs (checks) were all, except for maize, below one tonne per hectare: 395–920 kg/ha for barley, 465–750 kg/ha for durum wheat, 760 kg/ha for finger millet, 590–630 kg/ha for hanfets, and 480–790 kg/ha for teff (Annex in Edwards, 2003). In the seven-year data set, only hanfets had an average grain yield for the check below one tonne per hectare (858 kg/ha). The average check yields for all the other cereals ranged from 1 115 kg/ha for barley to 1 760 kg/ha for maize. By 2006, the four original communities had been making and using

FIGURE 8

Average grain expressed as percentage, in grain plus straw yields for seven cereal crops, Tigray, 2000–2006

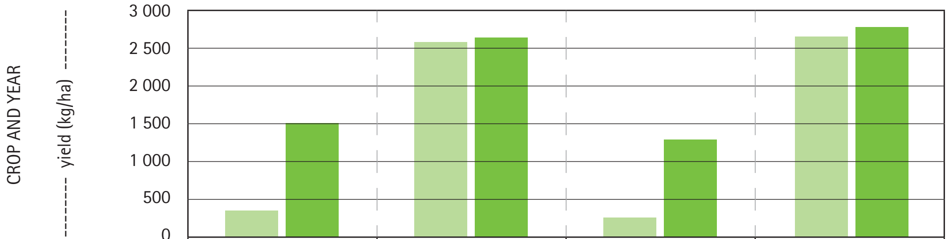


	NO INPUT (N=362)	COMPOST (N=324)	CHEMICAL FERTILIZER (N=228)
% grain	32.64	37.78	34.74

n=number of observations

FIGURE 9

Yields (kg/ha) for faba bean and field pea from Adi Abo Mossa, 1998 and 2002



	FABA BEAN 1998	FABA BEAN 2002	FIELD PEA 1998	FIELD PEA 2002
check	340	2 570	250	2 640
compost	1 500	2 630	1 280	2 770

compost for ten years, all the others had been using compost for three to five years, and the higher average check yields were probably due to the residual effect of the use of compost in previous years.

The impact of compost on restoring soil fertility is well illustrated by data for grain yields of the pulses, faba bean and field pea, shown in Figure 9 for Adi Abo Mossa. The difference between the yields for the check fields and fields that had received compost was very large in 1998, but in 2002 there was hardly any difference – for both crops and both treatments, the grain yields were over two tonnes a hectare (Tewolde Berhan *et al.*, 2004). This similarity in yields is also seen for field pea in the seven-year data set in Table 5.

Farmers rarely use chemical fertilizer for legume crops but these results show that compost can increase yields much above untreated (check) fields. The increased yields of leguminous crops from the use of compost are important for the farmers as these crops have high market values (see Tables 1 and 2). They are also important components of the diet since very little meat is normally consumed by smallholder farming households.

The residual effect of compost in maintaining soil fertility for two or more years was soon observed and appreciated by the farmers. They are thus able to rotate the application of compost on their cultivated land and do not have to make enough to apply to all their cultivated land each year.

The reduction of difficult weeds, such as Ethiopian wild oats, *Avena vaviloviana*, and improved resistance to pests, such as teff shoot fly, have also been noted by the farmers. These impacts from the use of compost, including better resistance to crop diseases, have also been found by farmers practicing organic agriculture in France (Chaboussou, 1985).

One reason that compost has been able to significantly increase yields could be the fact that the farmers are still using their own varieties (also referred to as landraces), which have been selected by them in an organic environment where overall soil fertility is more important than just the amounts of the two major nutrients, nitrogen and phosphorus, supplied by urea and DAP. Dr Stephen Jones (personal communication) of the Washington State University and his colleagues have been breeding wheat for organic agriculture and they find that varieties that give high yields under organic conditions are different from those that give high yields with chemical fertilizer inputs. The farmers of Adi Abo Mossa apply the highest rates of compost to their fields. By 2004, they were complaining of lodging in their fields that had received compost. There also seemed to be a levelling off in the increase in yields indicating the need for the farmers to be involved in participatory plant breeding in order to select varieties that could respond with higher yields under an organic production system.

Economic and social impacts of using compost

There have been many positive impacts on the lifestyles of farmers who have taken to adopting ecological farm management to give them sufficient biomass for making and using compost. Because they do not have the financial burden of taking chemical fertilizer on credit, several farmers, including women-headed families, have improved their houses, bought additional animals such as chickens and milk cows, and beehives.

Many farmers have diversified their crop production. One interesting innovation now widely taken up by other farmers is intercropping. A farmer in Adi Nifas who intercropped tomato and chilli pepper in his teff field set the example. Scattering other crops such as cress (*Lepidium sativum*) and oil crops into teff fields is a traditional practice. These crops continue growing up after the rains finish and do not compete with the teff much. This is also the case with the tomato and chilli pepper. There is a high demand for these vegetables, particularly at the end of the rainy season before the irrigated vegetable areas have started to produce them. The farmer who started the practice claimed to get more from selling his vegetables than from the teff. Several other farmers in the Adi Nifas and Adi Gua'edad areas have now adopted this and other innovative combinations of intercropping with teff.

One farmer in Ofla had to share-crop his land because he did not have plough oxen. He heard about the use of compost and convinced his share-cropping partner to use it. When the harvest was sold, the farmer got sufficient income to buy one ox. The next year, he was able to buy a second ox and give up share-cropping.

A very poor widow with five children was unable to send them to school or even join in social functions because none of the family members had basic socially acceptable clothing and she had nothing to contribute to the communal meals. She then grew the spice, coriander, instead of a food crop. This is a high value crop. After just one harvest, she got sufficient income to send her children to school because she could buy them the clothing that they needed and she could participate in social functions because she could buy the clothing and food that she needed for herself.

The special needs of women

Tigray has a high number of women-headed families because the long civil war that ended in 1991 was the most intense there. Much effort has been made in the project to include households headed by women because these are generally among the poorest of the poor in their villages. Traditionally, women should not handle plough oxen and they therefore have to wait to have their land ploughed by a male relative or a neighbour. This puts the single woman at a double disadvantage. Her fields are planted later, and each day's delay in sowing reduces the final yield. Then, at harvest time, the woman has to share part of the harvest with the farmer who ploughs her field. Such households never have enough food and are often unable to join in social activities or send their children to school because of lack of adequate clothing. A few women have taken up ploughing their own fields, but this has generally been at a considerable social cost with ridicule and ostracism levelled at them by their neighbours and relatives. They have even had their animals poisoned or mutilated. ISD and the local officials try to make sure that the poor women in the communities are included in all activities and their achievements are recognized.

In 2003, ISD suggested that the long season crops, finger millet, sorghum and maize, could be raised as seedlings in nursery beds and then planted out when the main rains started. This has been readily adopted by women, particularly for finger millet, as they can plant seedlings, rather than broadcast seed, when their fields are ploughed and they can thus overcome the disadvantage of late planting. The first woman to try transplanting got the equivalent of over 7.2 tonnes/ha from the part of her field where she had applied compost and transplanted finger millet seedlings. Direct sowing into the other part of her field where she had also applied compost gave the equivalent of 2.8 tonnes/ha. The number of farmers, both women and men, who transplant finger millet has steadily increased each year with most of them getting good yields.

In 1998, ISD decided to find out if supplying women with seed of spices, which are high value crops, could help poor women break out of their poverty trap. This has been the case and there is now a high demand from women each year for seed of spices. These women grow and sell the spices and get sufficient income to buy food and clothing for their families. This approach to supporting poor women has been taken up by other non-governmental organizations (NGOs) working in Tigray.

Many women find it difficult to prepare compost, mainly because they cannot dig the pits. ISD sometimes provides financial support for labour to dig these pits. However, during compost workshops, poor women-headed households are deliberately chosen to have pits dug and filled by the workshop participants, including themselves, so that they can get a boost to start making and using compost.

The other main constraint to making compost is the need for water. Collecting water for her household can take a woman around three hours for each trip. Often she has to make this trip twice a day. It is, therefore, not possible for a woman to collect water also for making compost or for growing fruits and vegetables. But she can use waste water from her household activities. Many local innovators have explored ways to dig shallow wells of up to 12 metres deep (but usually less than 5 metres deep) and have developed innovative ways of lifting the water out of these wells. ISD has provided support for these innovators to dig shallow wells for poor women-headed households, and then encouraged the women to grow fruits and vegetables. Again this has helped such women and their families get out of the poverty trap. This form of support has now been taken up by the BoARD and other NGOs working in Tigray.

The community of Adi Abo Mossa used another approach to compost making that ensured that women could also be included. Groups of around ten households make their compost in large communal pits. This makes it possible for the women to be included because they help with providing composting materials, and then with taking the compost to the fields. But this is the only community with such a pooled compost making system.

In 2005, the Tahtai Maichew Woreda Administrator asked for poor women-headed families to be provided with small animals (sheep or goats). Elsewhere in the region, this has been found to be one way of helping women get an income to improve their livelihoods. In all, 13 women (six from the town and seven from the villages) were each given one male and four female goats or sheep. This was on the basis of a revolving fund as each woman would return one female animal to be given to other poor women or men. Although almost all the women got at least one new lamb, the women in the town faced a problem of finding sufficient feed for their animals in the town. One woman said that she was planning to move back to her village with her sheep as she could then find feed more easily in her village area. In 2006, this approach was expanded to three other woredas through the Nile Basin Initiative: Transboundary Micro-grants Program. Granting of the sheep or goats was tied to the women agreeing to control their movements and feed them through a cut and carry system.

In 2004, leaders in Tahtai Maichew Woreda selected 30 girls and young women who had completed tenth grade for skill training for income generation. The training continued for two and half months with the graduation ceremony in January 2006. Of the 30 girls, half were trained in traditional food preparation and the other half in basketry and some embroidery. The standard of workership was very high in both areas, and some of the food items that had been made were quickly sold out to the local people who had come for the graduation ceremony. The head of the Tahtai Maichew Woreda women's affairs office assisted the young women to form a cooperative and apply for micro-credit to develop their own businesses. Training in traditional food processing was scaled up to other woredas through a grant to ISD from the Nile Basin Initiative Transboundary Micro-grants Program.

The challenges

The communities that have taken up the Tigray Project are neighbourhood groups of between 15 and 90 households. Each community belongs to a tabia (sub-district) of 300 to over 500 households. The tabia, with its "baito" is the lowest level of official administration. A "baito" is the tabia's council elected by the people and is responsible for the administrative and socio-economic functions within its jurisdiction. Thus, the baito plays a decisive role in local governance. Local collective decisions are codified in bylaws formulated by the members of a local community convened by its elected leadership. There may be more than one such local community in a tabia. Legal affairs are adjudicated by a social court of the tabia, though a local community does also enforce its own bylaws.

The woreda is the next higher level of administration. Each woreda has its own administration consisting of an administrator and a cabinet of five experts and advisors. All the main sectors of the government are represented in the woreda by experts. Woreda-level coordinators direct the activities of development agents, who are in day-to-day contact with the farmers. It has been very important from the beginning that the woreda officials, experts and development agents understood and supported the aims of the project for its effective implementation.

At the level of the farmers, the improvements in livelihoods from the Tigray Project have been readily appreciated. However, these improvements, particularly the management of the natural resources in both the cultivated and uncultivated parts of a catchment as a whole, are bringing out challenges because a small community can develop and apply its own local bylaw only to its own members, but in order to resolve conflicts and problems with neighbouring communities, the local bylaw needs recognition and support from both the baito of the tabia, as well as from the woreda.

Local community level bylaws have established local committees to oversee the implementation of the project. These committees meet regularly to discuss and make decisions for local management. They have also set up a system of penalties for farmers who trespass their bylaws; for example, by letting their animals graze in protected cultivated and non-cultivated areas or cutting grass when they have not been authorized to do so.

Restricting grazing

The most challenging aspect of the project to implement has been restricting the grazing of cattle, sheep and goats.

Traditionally, only plough oxen, milking cows and young stock get special feeding treatment; all other domestic animals have to find feed for themselves. The animals are turned out in the morning and are guided and guarded by children during the day, including being driven to communal drinking places. In most parts of Tigray, there has been a drastic reduction in the areas of common grazing land as the demands for cultivated fields have increased with the increasing numbers of farming households. Traditionally, after the harvest is collected, the animals range freely over fields and patches of natural vegetation, while crop residues are kept on tops of houses and small trees or in specially fenced parts of the compounds for feeding special animals. This system of free range grazing has helped drive the deterioration of the environment as the animals trample more than they eat, destroy seedlings of woody plants and break down physical structures constructed for soil and water conservation.

It was, therefore, seen as essential that animal grazing had to be restricted if attempts to allow hillsides to be re-vegetated and increase biomass were to succeed. In fact, in the 1980s many of the villages in Tigray had already instituted a system whereby communities identified hillside areas as enclosures keeping out grazing animals as well as people and the native trees and grasses re-established. But, up to 2005, neither the region nor the woredas had developed a system or systems for the sustained use of the biomass of the enclosures. Hence farmers changing from free range grazing to cutting and carrying for their animals have not always found it easy to protect their recovering vegetation from free range grazing animals from neighbouring villages. With more communities adopting the restriction of animal grazing and with all levels of government throughout the country recognizing community bylaws, this problem is on the way to being solved.

One unexpected positive aspect of changing the grazing management has been the opportunity for children to go to school. ISD has heard that children who are required to stay out of school to herd animals resent this and it can cause division in families. Changing grazing management for families without children, such as elderly couples, is also a major problem as they do not have the time or energy to cut and carry feed for their animals.

The problem of restricted grazing was raised in a meeting in Tahtai Maichew in August 2005 and again in a compost training workshop in September 2005. The first was a meeting of around 40 farmers who had expressed their dislike of the Tigray Project. Most of these farmers were better off and had larger herds of animals than their poorer neighbours. They had only seen the project in terms of restrictions and had not realized the positive environmental impacts of controlling grazing on improvements to the general productivity of their areas, and particularly to the improvements to the local hydrology. After a long and intense discussion lasting half a day, the farmers agreed that they would try and cooperate with the aims of the project and control the movements of their animals.

The discussion in the compost training workshop in September 2005 emphasized the importance of having cooperation among farmers. The farmers stated their awareness of the importance of controlling the grazing of animals, but, they pointed out that their neighbours do not restrict the movements of their animals, and the local authorities, the baito committees and social courts, do not uphold the bylaws of the communities and help in penalizing the farmers that break the grazing rules. Therefore, they were not all prepared to control the grazing of their animals unless this could be enforced throughout their communities, i.e. by the baito.

However, the advantages of restricting grazing and using cut and carry is gradually being seen by many farmers. All the levels of government, supporting the BoARD, are working to convince farmers to restrict the free range grazing of their animals, and the regional government has adopted a policy called 'zero grazing'. This has brought a new challenge – the need for improved and easily available forage on the bunds between the fields as well as in the rehabilitated gullies. *Sesbania* and tree lucerne (*Chamaecytisus proliferus*) are popular, some farmers have also introduced pigeon pea (*Cajanus cajan*), while elephant grass is being widely planted. In many communities, starting from Adi Nifas, the farmers have introduced local species of tall thatching grasses (*Hyparrhenia* spp.) on the bunds. But the demands for seed and planting material are much higher than the ability of local institutions to make them available. It is also becoming clear that research and development is needed to further intensify the economic productivity of the whole local ecosystem with emphasis on the areas dependent solely on rainfall.

Forests

Traditionally, local communities usually have some form of common law (unwritten understandings and systems) for using their natural resources, particularly water resources and trees. But these common laws are not written and it has sometimes been difficult to have them recognized by the formal codified (written) legal system of the country; a hangover from the history of the centralization of state power of the nineteenth and early twentieth centuries. Until the development of the system of enclosures by local communities, the best protected areas of natural vegetation were the small patches of sacred forests around churches and monasteries, in Muslim burial grounds and around holy springs. These areas have been protected by the strong beliefs of local people, not through official guarding.

The other forest/woody areas are "community forests", mostly of eucalyptus planted during the military government of the 1970s or early 1980s. After the change of government in 1991, local communities throughout the region have designated hillside enclosures where indigenous tree and shrub species, particularly acacias and some juniper and olive, have regenerated.

One of the major challenges for the government is the increasing number of landless people who need alternative sources of income. There is also a strong push from the government to bring the farmers into the monetized economy through the development of markets. Local communities are being supported to build roads, and areas by these roads are being given to landless families to form small settlements, build houses and set up shops and markets. This is increasing the demand for wood to build houses. Often, arrangements are made for the new homeowners to buy and build their houses using eucalyptus. However, the demand for wood, particularly good quality wood which is durable and termite-proof, is very high. The preferred timber trees are juniper and olive. Usually the only places where juniper and olive trees of usable size are still found growing are in sacred forests. Despite the strong religious taboos, reports of old olive trees being cut to make new houses were brought to the attention of ISD and the local authorities in 2005. The threat to sacred forests was surveyed and it was found that there are many pressures being used by some local people to get access to the valuable timber in these forests. Although the BoARD, particularly the Department for Natural Resources and Environmental Protection, had developed guidelines for protecting forests, these were not being fully implemented because the local judiciary and administration at both tabia and woreda levels were not recognizing the bylaws of local communities. Now, in 2009, bylaws are recognized and their enforcement is being supported by all levels of government in the region.

Farmers' experiences in the project

At the start of the project, farmers were reluctant to plant trees around their farms, thinking that they would attract birds and shade their crops. But after they saw the impact on the health of their animals of having more forage available, particularly from *Sesbania*, the small multi-purpose tree legume, and appreciated that the trench bunds and check dams stabilized the land, they readily planted more trees. Many farmers have started to also plant fruit trees, both around their homesteads and in rehabilitated gullies. There is now a steady demand for fruit tree seedlings by the farmers and new nurseries have been developed to meet this demand.

Farmers have started diversifying their production once the quality of their land has improved; for example, through innovative intercropping, as already described. Another farmer reintroduced a special barley variety called "demhay", which is used to make a popular snack of roasted grain called "qolo". Overall, the diversity of most crops has increased in all the communities in the project.

In Ziban Sas, after the grazing area was restored in 1998, the farmers asked for other improvements, particularly a pond for watering their animals as the community is on a small plateau and the animals had to be taken several kilometres down into the valley below to get water. The first pond was only moderately successful because it was small and leaked. Starting in 2004, a much larger pond was constructed and provided with a cement lining. It was completed in 2005. Helping communities to construct communal ponds has now become a regular feature in the project's work plan.

Farmers, development agents and experts, local administrations and ISD staff have identified the following as the positive effects of the Tigray Project:

- Crop yields are as good as, and often better than, those obtained by using chemical fertilizer.
- Agro-biodiversity is maintained and improved. For example, in 1996 the farmers of Ziban Sas were growing only a durum wheat-barley mixture called 'hanfets' and a little teff, but now other crops such as maize and faba bean are also grown. Obviously this will make their agricultural system more complex and thus more likely to be resilient to climate change.
- Both biomass and biodiversity increase in the areas protected from free range grazing, with many plant and animal species that had disappeared from the local ecosystems

returning; for example, Aardvark, which digs up termites. The improved vegetation cover protects the soil from erosion and provides good bee forage, helping the farmers and their ecosystems become more resilient to climate change.

- Weeds are reduced in fields where compost has been applied – weed seeds, pathogens and insect pests are killed by the high temperature in the compost pits, but earthworms and other useful soil organisms establish well. Weeds that do well on poor soils, such as wild oats (*Avena vaviloviana*) and striga (*Striga hermonthica*), are much reduced in soil fertilized with compost.
- Increased moisture retention capacity of a soil – if rain stops early, crops gown on soil treated with compost resist wilting for about two weeks longer compared to fields treated with chemical fertilizer. This is crucial during times of drought, which remains a recurring problem in many parts of Ethiopia, especially along the east.
- Plants grown with compost are more resistant to pests and diseases than crops grown with chemical fertilizer.
- Residual effect of compost – the positive effects of compost can remain for up to four years. The farmers have realized that, in contrast to chemical fertilizers, they do not need to apply compost each year as after adequate amounts of compost have been applied in one year, they can obtain good yields from their crops for the next two to three years without applying compost afresh.
- Farmers have been able to get out of debt from buying chemical fertilizer – the economic returns from making and using compost are positive as farmers have been able to stop buying chemical fertilizer, but they get even higher yields.
- Foods made from grain grown in fields fertilized with compost are said to have a better flavour than foods made from crops grown in fields treated with chemical fertilizer.

Each project site has its distinctive features and problems, and the outcomes achieved are also distinctive. However, in general for all project sites, the environment has been rehabilitated, food and feed production greatly improved, tree and grass cover as well as biodiversity returned, and soil protected from erosion. By 2008, the BoARD claimed that soil erosion in the region had been reduced by over 60 percent.

SCALING UP THE TIGRAY PROJECT

Institutional ownership

Since it started in 1996, the Tigray Project has been accepted by the agricultural professionals in the BoARD and implemented in partnership with the ISD in collaboration with the respective woreda administrations and agricultural experts and development agents that work with the local farming communities. The Project Officer was one of its experienced extension officers assigned to the project by the BoARD. In 2002, the Project Officer was retired and became a full time staff member of ISD, retaining strong working relations with the Bureau. Hence, ISD has deliberately not set up a separate system to implement activities. Instead, ISD facilitates some inputs, gives advice, runs workshops and makes careful follow-up with all its local actors.

Since 2003, ISD and the BoARD have also worked closely with the EPA in its Land Rehabilitation Project.

Steps in the scaling up process in Tigray

The Gu'emse community was the focus of the annual farmers' field day in October 1998, and this encouraged the senior members of the BoARD to promote the "sustainable agriculture package" as part of the extension programme to improve food security for the region. This was the start of scaling up of the project's activities. Efforts were made to extend the project's activities to 90 communities and have 2 000 farmers making compost by the year 2000. This was only partly successful mainly because local experts and development agents lacked the required training in compost making.

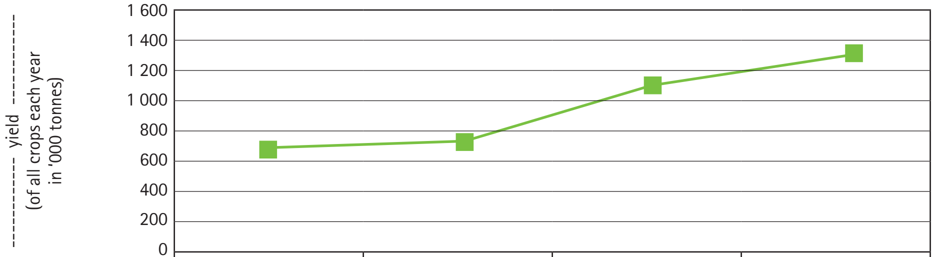
As part of the scaling up process, ISD published in 2002 a booklet on compost making written in Tigrinya (the regional language of Tigray) by Arefayne Asmelash (1994 EC/2002 GC), followed by a poster in Tigrinya published in 2007. Although the guidebook and poster have been distributed widely, farmers, development agents and local experts need to have practical training and visiting of farming communities where compost has been used successfully in order to feel confident that they themselves can make and use compost effectively. Therefore, as of 2005, ISD changed its training approach to include at least 50 percent participation by farmers as trainers-of-trainees (TOT) in the making and using of compost alongside the agricultural professionals. The farmers were charged with the responsibility of training a minimum of ten of their neighbours in making and using compost with the agricultural professionals doing the follow-up monitoring of the model farmers. Trainer farmers who fulfil their obligation are awarded certificates, while those who succeed in training many of their neighbours also receive tools. Through this approach, two outstanding farmers, one a woman and the other a man, have managed to train over 30 of their neighbours in making and using compost.

The interest and support of the woreda administration is also important in scaling up. In Tahtai Maichew, the woreda administration approached ISD and EPA in 2004 to help it bring the whole of the woreda into the Tigray Project. The scaling up started in July 2004 with a four-day workshop involving over 200 farmers. Each of the local experts introduced an aspect of the project, followed by two farmers describing how the activities in question had improved their livelihoods. Leading farmers from neighbouring communities were trained and encouraged to train other farmers in their neighbourhood, so that there could be a rapid increase in the numbers implementing the activities of the project, particularly restricting free range grazing and making and using compost. By 2008, 26 communities from all the 20 tabias of the woreda were implementing the project and the neighbouring woredas around the towns of Axum and Adua had also joined the project. The aim is to develop a rehabilitated “green belt” about 80 km wide, west to east, with all the farming communities practicing ecological agriculture across what was until recently a degraded landscape.

The new training approach of focusing on farmers as trainers has also led to rapid scaling up in the making and use of compost throughout the region as reflected in Figures 10 and 11.

FIGURE 10

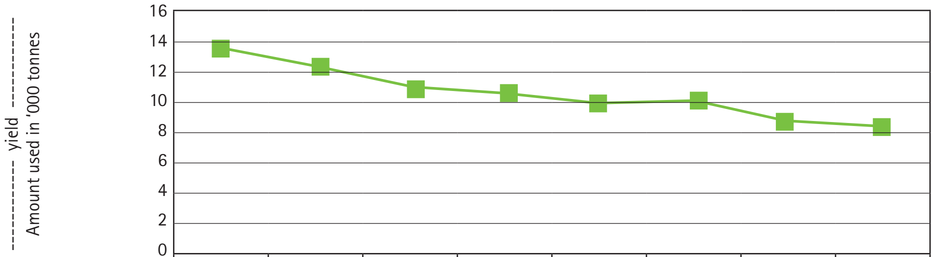
Total recorded crop production in Tigray, 2003–2006



	2003	2004	2005	2006
crop yield in '000 tonnes	713.95	716.96	1 162.20	1 353.79

FIGURE 11

Total use of urea and DAP in Tigray, 1998–2005



	1998	1999	2000	2001	2002	2003	2004	2005
crop yield in '000 tonnes	13.71	12.43	11.54	11.32	10.09	10.17	8.90	8.17

The official crop sample survey of Ethiopia for the crop year 2007–2008 showed that 86 percent of the nearly 700 thousand farmers in Tigray were using natural fertilizer on nearly 200 thousand hectares. Only 16 percent of the farmers had used chemical fertilizer on 48 thousand hectares. In the same crop year, the total production of cereals in Tigray reached 117 thousand tonnes with increases of between 12.7 and 15.9 percent for the major cereal crops. The implication from these data is that the bulk of this production was organic.

Steps in the scaling up process in other parts of Ethiopia

ISD's scaling up experience

The spread into Meqdela Wereda of South Wollo Zone in the drought prone eastern part of Amhara Region came about in 2004. Meqdela is the home area of one of the staff members of ISD, and he had talked about the Tigray Project when he had visited his family in Masha, the capital of Meqdela. In February 2004, six farmers, two local experts and two representatives from the local administration, including the woreda administrator, visited the Tigray communities, and four more participants came to a compost workshop in Axum in August 2004. When they returned to Masha, the local administrator encouraged the farmers to become local trainers with the aim of having 28 000 farmers in ten kebeles (parishes) in the woreda restricting free range animal grazing and making and using compost by the next growing season of 2005. Meqdela Woreda was visited in November 2005 and the impact of applying ecological agricultural practices was striking. As well as making compost, the farmers had started water harvesting, growing vegetables, and protecting hillsides from grazing. The local administration also changed a tree nursery into a nursery for producing fruit trees and forage plants. In 2005, Meqdela Woreda was awarded a prize by the Amhara Regional Government because of its efforts to rehabilitate its environment and improve the lifestyles of its farmers. It was the push by the local administrator for the farmers to become trainers in making and using compost that helped ISD adopt this approach in its own training programmes.

Scaling up has also been started in Gembichu of East Shewa Zone of the Oromiya Region, 45 km east of Addis Ababa. Two farmers had taken part in the big workshop in Axum in November 2001, and had been applying compost and fermented dung to their fields since. In September 2004, the farmers were invited to a workshop on seed saving where they challenged ISD to work with them. Compost making workshops have been held regularly since and one of the farmers formed a local neighbourhood group of 20 farmers committed to making compost. This group is also a Crop Conservation Association mandated to produce elite seed of farmers' varieties based on organic principles. In 2005, the administrator and experts of Gembichu Woreda requested ISD and EPA to include the woreda in their programme. Work has now been going on to get the whole woreda into an organic system of production.

EPA's scaling up experience

The first major event in the scaling up process into other regions of Ethiopia was a workshop held in Axum hosted jointly by ISD and the BoARD together with the Innovative Soil and Water Conservation Project of Mekelle University. This took place in November 2001 and representatives from all regions of Ethiopia as well as other NGOs working with farmers were invited. Over 40 farmers were also present. The papers presented included the first set of yield data from the use of compost in farmers' fields. The workshop also included field visits to the farms and farmers in Adi Nifas and to innovator farmers including one who had developed an ingenious lifting device to get water from a well 12 metres deep. He had used the water to develop a fruit and vegetable garden. This workshop stimulated experts from the EPA to develop a project for land rehabilitation with support from the United Nations Development Program (UNDP) under the Country Cooperation Framework Programme.

The Land Rehabilitation Project was launched in a workshop in Axum in October 2003. The aims of the project and the steps to achieve it were discussed and a field visit was carried out to Adi Nifas. The plan in the first phase of the project was to have communities from three woredas from each region, except Addis Ababa, start to implement the principles of the Tigray Project, but adapted to the local situation. The project was successful and a second five-year phase was launched, 2006 to 2010. This phase plans to include communities in 45 woredas in all regions and is based on each woreda developing and implementing a woreda environmental management plan based on their local community environmental management plans supported by appropriate local bylaws (EPA, 2010). The aim is to:

- Integrate environmental concerns in all development work at the local level;
- Ensure that agricultural production is based on ecological principles with reduced dependency on expensive external inputs;
- Fulfil Ethiopia's national obligations to the various global environmental conventions;
- Contribute towards the implementation of the Environmental Policy, and the Agricultural and Rural Development Policy of Ethiopia; and
- Improve rural livelihoods.

Between July 2006 and June 2008, communities in 27 woredas had initiated developing and implementing their respective environmental management plans. These woredas are in Afar, Amhara, Benshangul-Gumuz, Dire Dawa, Oromia, Southern Nations, Nationalities and Peoples, and Tigray Regions. By 2010, between 18 000 and 20 000 households will have benefited from this project, giving a total of around 100 000 beneficiaries.

The project works closely with the Extension Program of the Ministry of Agriculture and Rural Development as well as a number of non-governmental actors: local NGOs, the Small Grants Programme of the Global Environment Facility (GEF), the Nile Basin Initiative, the Global Mechanism of the United Nations Convention to Combat Desertification (UNCCD) and the Norwegian Development Fund.

In order to accommodate the challenge of providing training in the making and use of compost, ISD has developed a package of training materials and methodology for running compost making workshops as well as for follow-up.

The package includes the manual and an accompanying poster on making compost in Amharic, Oromiffa, Tigrinya, and English, a 30 minute video/DVD in Amharic, 30 annotated slides as a Power Point presentation, and a brochure describing how to organize and conduct a compost training workshop, and monitor the impact of its use in farmers' fields. EPA has supported ISD in getting the materials printed and distributed.

The experience from the Tigray Project has thus been expanded throughout Ethiopia by the Ministry of Agriculture and Rural Development through its extension system together with the EPA and ISD. Data gathered by the Ministry of Agriculture and Rural Development show that, in the year between the middle of 2007 and 2008, about 1.8 million hectares of farmland (about 16 percent of the total in the country), cultivated by about two million farming families (also about 16 percent of the total in the country), were fertilized with compost. Since a farm needs compost only every two to four years, this means that at least a third of the farmland in Ethiopia is organically fertilized. Towards the end of November 2008, a conference aimed at expanding the experience of the Tigray Project to other countries in Africa was convened by the African Union. The conference, which was held in Addis Ababa, was preceded by field visits to some of the Tigray Project sites near Axum in the Tigray Region.

Workshops and cross visits

The best person to convince a farmer to take up compost making is another farmer, and similarly, the best person to convince an expert or administrator of the value of the Tirgray Project is another person already involved in the project at the same responsibility level. For farmers, it is seeing that is believing, but this is also true for trained professionals. ISD has, therefore, invested time, energy and funds into developing good workshops and taking representatives from all levels in a woreda to meet their counterparts in another woreda where the project is being implemented. These are referred to as cross visits.

Through these workshops and cross visits, the development agents and local experts gain confidence to help the farmers make good compost and the relationship between them and the farmers changes from one of imposition to one of support and advice. All stakeholders also actively participate in evaluating the effectiveness of the activities of the project.

Compost workshops are now held regularly at the end of the growing season, i.e. from late August to early October, because this is the time when there is adequate green biomass available. Typically they last for three days and include a field visit as well as practical training and discussions. Therefore, the numbers of participants are kept below 50 and the practical work is done in groups of 10–15. Everyone is expected to physically contribute to filling up a compost pit. The discussions raise issues of what constitutes ecological agriculture and any special challenges faced by the farmers. Through these workshop opportunities, ISD has been able to hear and discuss the views of farmers on food security and on ecological agriculture, traditions in selecting and keeping seed for sowing, and preferred indigenous trees for animal feed and other uses. The workshops bring together farmers and local experts from different areas resulting in vigorous exchanges of views and experiences.

With the farmers being encouraged to become their own trainers, the technology can spread fast throughout a community. This is done by farmers committing themselves to train at least ten of their neighbours, and those trained also commit themselves to train other farmers. This can initiate a training chain so that all the farmers within one area make and use compost.

CONCLUSION

The experience in Tigray from the Tigray Project has been very positive, both in terms of helping farmers improve their livelihoods and in showing local experts, administrators and policy makers that environmental rehabilitation is basic to improving the productivity of crops and livestock. Use of ecologically sound organic principles can have very quick positive impacts on the productivity and well-being of smallholder farmers so that they do not necessarily have to face a conversion period of reduced yields as they change from chemical to organic production.

Most farmers, particularly those in degraded and drought prone areas, are not able to afford external inputs. For them, an organic production system offers a real and affordable means to break out of poverty and obtain food security.

It is important to bear in mind that although it may be external market interests that initially stimulate the development of a policy environment for organic agriculture, the benefits should be available to all members of society to build a healthy and food-secure future for Ethiopia.

While challenges undoubtedly still lie ahead, the positive experiences from Tigray and elsewhere in the country where farmers are using ecological/organic agriculture practices provide hope for Ethiopian farmers and improved food security for the country as a whole. Modified to suit local conditions for farmers in other parts of Africa, the lessons learnt from the Tigray Project could also bring substantial benefits to their local communities and the world of the future.

Considering the growing need for, and importance of, ecological agriculture, it is time that the research and development institutions of Ethiopia, Africa and the rest of the world take it seriously and breed varieties appropriate for it. Their approach should take advantage of the skills of smallholder farmers as participating partners in plant breeding, and of other methods to intensify ecologically sound crop management systems.

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