Swedish Society for Nature Conservation

Report
Ecological in Ethiopia

– Farming with nature increases profitability and reduces vulnerability

Text: Jakob Lundberg and Fredrik Moberg, Albaeco
Production: Albaeco
Graphic design: Christine Clifstock, Clifstock Form
Project management: Karin Höök, Swedish Society for Nature Conservation (SSNC)
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Foreword

Agriculture world-wide must change its course to promote the international targets on eradicating poverty, decreasing hunger and sustainable development in general. Agriculture in all the world's countries must be based more on ecosystem services than on fossil fuels. Only then can access to food and water for all be secured, climate change limited and biological diversity protected.

In the increasing flow of documents on climate change and other serious environmental disruptions, the Swedish Society for Nature Conservation wishes to present a particularly positive example in this report. We describe an agricultural project in northern Ethiopia that has succeeded in reversing the developments in an area formerly severely affected by problems such as soil erosion and hunger. Here, poor subsistence farmers, researchers, local advisors and agricultural experts and the environmental organisation Institute for Sustainable Development – which is supported by the Swedish Society for Nature Conservation – have together devised a cropping system which is based on local inputs, biological diversity and other ecosystem services. The project has produced a range of positive results such as higher yields, higher groundwater levels, better soil fertility, decreased susceptibility to drought, increased income and better opportunities to make a living.

The report concludes with the Swedish Society for Nature Conservation's recommendations, which we hope can inspire practitioners, politicians and many others to make decisions that promote sustainable development. A range of comprehensive reforms are necessary, not least within aid and research.

This report was prepared by Albaeco on the commission of the Swedish Society for Nature Conservation. Work on the report was carried out within the framework of the Swedish Society for Nature Conservation's international environmental policy programme, in collaboration with Albaeco and researchers from Stockholm University and the Swedish University of Agricultural Sciences. It would not have been possible to produce this report without the valuable help we received from the Ethiopian environmental organisation Institute for Sustainable Development and its staff – and from local farmers and agricultural advisors in Tigray. The Swedish Society for Nature Conservation warmly thanks all those involved.

This is a first report in a series that will highlight positive examples of how agriculture can be structured so as to contribute to sustainable development, with the focus on securing access to food for the world's growing population and the environment on which we are all fundamentally dependent.

Mikael Karlsson
President of the Swedish Society for Nature Conservation (SSNC)

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Small-scale agricultural landscape in Tigray, northern Ethiopia. Here, a successful example of sustainable agriculture has resulted in reduced soil erosion and higher yields. Photo: Anneli Nordling

1. Introduction

This report describes a successful example of sustainable agriculture in Northern Ethiopia where stakeholder involvement and support to local farmers have been key. The project, which goes under the name of the Tigray Project, has achieved a range of positive results in a region that has previously been severely affected by soil erosion and decreasing yields. Experts from local to national level together with the farmers in the region have devised a farming system that is based more on biological diversity – particularly the rich knowledge and agrobiodiversity of the farmers – and ecosystem services (see Box 1) than on fossil fuel, in order to provide a long-term secure food supply and ecologically sustainable agriculture. The project, which is primarily directed at small farmers with around one hectare of cultivated land, has resulted in e.g. higher yields, higher groundwater levels, better soil fertility, increased household income and stronger livelihood opportunities for women. The government has now adopted the approach used in the project to mitigate soil damage and to alleviate poverty in 165 local districts in the grain-producing parts of Ethiopia.

Role of ecosystems in securing access to food

Providing a long-term food supply for a growing global population without this resulting in damaging effects on both climate and ecosystems is one of the greatest challenges facing mankind. It will demand considerable changes in existing resource use patterns and cultivation systems. The rationalisation of forestry and agriculture over the past century or so has admittedly led to unprecedented economic development, increased yields and a reduction in poverty for many people, but it has also meant that the natural systems on which we depend are now so critically stressed that they are losing their ability to supply benefits, so-called ecosystem services, to our societies. This is already giving rise to a number of undesirable effects, such as water deficiency, hunger, considerable losses of biological diversity and a steadily growing number of climate refugees. Despite a range of improvements, three out of four of the world's poorest people, totalling up to a billion people, live in rural areas in developing countries and run a constant risk of being severely affected if crops fail or cattle die.

The poor and hungry, to a greater extent than others, are directly dependent on functioning ecosystems and those services that the local ecosystems supply for their survival. The world-wide decline of insects that pollinate important agricultural crops is one of many examples of how the ecosystem services on which mankind relies are now being threatened. Agriculture is also reliant on a number of other ecosystem services such as water purification, natural pest control and maintenance of soil fertility. Continued weakening of ecosystems can therefore have considerable consequences for future food security and restrict the potential to attain the UN Millennium Target of halving the number of people suffering from hunger and chronic malnutrition by 2015.

In recent years a range of reports, with the UN Millennium Ecosystem Assessment (MA) at the forefront (see Box 3), have shown how the ability of ecosystems to secure human welfare has declined. At the present time, 60 % of ecosystem services are already being overexploited or threatened due to e.g. damage to habitats, invading species, eutrophication and environmental pollutants. The accelerating changes in world climate pose an additional threat. According to the UN Intergovernmental Panel on Climate Change (IPCC), large areas of e.g. Africa could be stricken by yield decreases of over 50 % by the year 2020 as a result of an increasingly hotter and drier climate.

Furthermore, during the coming 50 years the global population is expected to increase by 60–80 million people per year and the greatest increase will occur in sub-Saharan Africa. These people will all require secure access to food, just like the current over 800 million people who already do not have sufficient food for their daily needs. In other words, increasing amounts of food will be needed while at the same time the use of fossil fuel – which is the basis of today's intensive agriculture – will have to decrease due to climate change. The cost of fossil fuel is also expected to increase dramatically due to declining reserves. In the light of all this, developing a form of agriculture that is based to a greater extent on ecosystem services than the present industrial model appears to be an increasingly attractive solution, since if designed correctly it could decrease the need for fossil fuel and also render agriculture less vulnerable to climate change.

Box 1: Ecosystem services

Ecosystem services are all those benefits that ecosystems provide. Human wellbeing and development are completely dependent on these services, for example purification of air and water, climate stabilisation, erosion control, pollination of crops, natural pest control, providing essential products including food, fibre, fish and timber, and the ability to mitigate the effects of natural disasters.

Within the Tigray project, farmers have used a number of innovations to overcome overgrazing, soil erosion (see small picture) and depletion of water resources. Photo: Jakob Lundberg

The Tigray Project

The Tigray Project began as an experiment in sustainable development and ecological farming in Tigray, the most northerly state in Ethiopia. Here, experts from local to national level together with the region's farmers have begun to employ a number of sustainable cultivation methods in order to restore the water balance and decrease the need for artificial fertilisers, while reversing the effects of overgrazing, soil erosion and damage to water courses. Since the start in 1996 until now, the project has been managed by the Institute for Sustainable Development (ISD), the Bureau of Agriculture and Rural Development (BoARD) in Tigray, Mekelle University, the local communities and their local authorities. The aim is to help farming families increase their productivity through rehabilitating their environments, create improved livelihood opportunities and prevent the famine disasters that have previously often affected the region in conjunction with recurring periods of drought.

The methods introduced by the Institute for Sustainable Development (see Box 2) in collaboration with farmers and the local authorities, also have the advantage that they utilise available local resources and farmers' knowledge. In this way they eliminate the need to use fossil fuel in the form of chemical fertilizers. In addition, they contribute to making the local population better equipped to deal with future climate change. The activities carried out within the project include:

- Training in how compost can be made and used to recycle nutrients and eliminate the need for artificial fertilisers (gives more stable and fertile soils with increased water-holding capacity).
- Making trench bunds between fields and construction of upstream check dams in gullies to hold water and soil, and decrease the rate of water flow to reduce soil erosion.
- Creation of ponds and small earth or stone and cement dams to collect water for the dry period.
- Training in small-scale traditional food processing for unemployed young women who have completed their schooling.
- Strengthening protection against uncontrolled movement of domestic animals and overgrazing on slopes and other sensitive areas.
- Planting of multipurpose trees (particularly *Sesbania sesban*, which provides forage, fuel and shade, while also acting as an erosion barrier and natural nitrogen fertiliser).
- Reintroduction of indigenous grass species in order to decrease soil erosion and increase the water-holding capacity of the catchment area.
- Support for poor women-headed households.
- Supplying seeds and seedlings to plant fruit and vegetable gardens (fruit trees, bushes, vegetables and medicinal plants are particularly in demand).
- Support for low technology solutions to improve access to water in the dry season, such as rainwater harvesting (collecting and saving rainwater for use during dry periods) and foot pumps.

The four communities that were included in the first phase of the Tigray Project chose to focus on the issues they considered to be the most urgent for their area. This led to the development of a range of different strategies and a flexibility that probably contributed to the success when the project was extended in stages to other districts in Tigray and then to other regions of Ethiopia. There are great advantages in being open to suggestions and being flexible when new management programmes are being introduced, so as to meet local needs, increase engagement through utilising farmers' knowledge and testing the way forward to achieve the best results.

By 2008 the principles of the Tigray Project regarding

Tewolde Berhan Gebre Egziabher and Sue Edwards – the initiators of the Tigray project. Photo: Anneli Nordling

Portrait 1: Tewolde Berhan Gebre Egziabher and Sue Edwards – initiators of the Tigray Project

Husband and wife Tewolde and Sue are the inspiration behind the Tigray Project. Tewolde has devoted most of his life to issues relating to the preservation of biological diversity and the rights of Ethiopian farmers to their own genetic resources. For the latter, he won the alternative Nobel prize, the Right Livelihood Award, in 2000. His long and chequered career ranges from taking his doctorate in Wales to being director of the Ethiopian Environmental Protection Authority. Sue Edwards, who was born in England but who has been living in Ethiopia since 1968, is the director of the Institute for Sustainable Development (ISD) in Addis Ababa – the organisation behind the Tigray Project. She is a botanist specialising in taxonomy, but also a lecturer, science journalist and editor of Flora of Ethiopia and Eritrea, a seven-volume work that aims to describe the 6500-7000 plant species found in the region. She is passionate about the importance of involving Africa's farmers as full partners in any developments to improve agricultural production in Africa.

Box 2: Institute for Sustainable Development (ISD)

The ISD began its activities in a shared project with local farmers, the Bureau of Agriculture and Rural Development (BoARD), and Mekelle University in the Tigray Province in Northern Ethiopia in 1996. The aim of the ISD is to help farmers improve their environment and productivity with the help of ecologically based methods for natural resources management. Today (2008), this model has spread to more than 25 % of the farming communities in Tigray, and 165 districts throughout the grain-producing areas of Ethiopia. The ISD is also working with environment clubs in schools and out-of-school urban youth groups where training and support to maintain and enhance cultural and biological diversity and agriculture are some of the cornerstones. The ISD is also working together with the Ethiopian Environmental Protection Authority, for example in order to introduce better protection of the rights of local communities and to strengthen their rights to conserve and utilise their natural biological resources.

soil improvement measures had begun to be applied in more than 165 communities in the grain-producing regions of Ethiopia. This expansion was made possible through continuous collaboration with local farmers, farming experts and rural development workers at various levels. This collaboration involved initiating workshops, producing information material and encouraging farmers to train one another and exchange experiences. Great consideration has been given throughout the project to adapting the methods to the local conditions. The project is managed by everyone from local farmers via agricultural authorities to the Ethiopian Environmental Protection Authority with some strategic support from the UN Development Programme (UNDP). Other important sources of support for the ISD have been the Third World Network from the start of the project to the present, and the Swedish Society for Nature Conservation since 2005.

a) Pollination of lime and other fruit trees is an example of a crucial ecosystem service for agricultural prodution in Tigray. Several of the methods used in the project enhance pollination and other ecosystem services. b) Wahad Gurastay. Photo: Anneli Nordling.

2. A form of agriculture based on local resources and ecosystem services

Agriculture both generates and is dependent on a range of ecosystem services such as pollination, water purification, natural pest control and maintenance of fertile soils. Avoiding depletion of global ecosystems is therefore decisive for future food security in order to decrease the number of starving people in the world. The Tigray Project is an example of how agriculture can be developed so that it promotes the production of ecosystem services and minimises the impact on the climate.

According to the UN Millennium Ecosystem Assessment (see Box 3), 60 % of the planet's ecosystem services are currently overexploited or threatened due to e.g. damage to habitats, invading species, eutrophication and environmental pollutants. The changes in global climate pose an additional threat. Industrialised farming is one of the main reasons behind the degradation of ecosystem services. In light of this, a growing number of voices are calling for a form of agriculture based on local inputs, biological diversity and maintained or improved ecosystem services. Correctly designed, this could decrease the need for fossil fuel and also make agriculture less susceptible to climate change.

Future agriculture must be based more on biodiversity and ecosystem services than fossil fuels

The Tigray Project draws benefit from the free services of nature

The farmers in the Tigray area benefit from a range of ecosystem services in order to achieve a long-term sustainable food supply in combination with ecologically sustainable agriculture (see Table 1). Wild species in the area contribute services such as pollination, natural pest control, purification of water and recycling of nutrients. Biological diversity and the ecosystem services provided thus decrease or eliminate the need for artificial fertilisers and pesticides. Instead of artificial fertilisers, compost is used to recycle plant nutrients to the land in a natural way. Plant nutrients are also provided through the farmers growing legumes (e.g. faba bean), which enrich the soil thanks to their ability to utilise the nitrogen in the air (biological nitrogen fixation).

Can this type of ecosystem services-based agriculture really provide sufficient food for an ever increasing population? Dr. Tewolde Berhan Gebre Egziabher, 'the godfather of the Tigray Project', has no doubts: "I am convinced that organic farming can provide us with sufficient food. Previous farming societies have done so for thousands of years. With our increased knowledge we ought to be able to succeed better than them".

Dr. Tewolde personally believes that the rationale behind the project is to "support and enhance rather than disrupt the natural cycles that support the functions of the ecosystem as a whole".

The poor farmers who are involved in the project have obtained very promising results through using sustainable farming methods such as composting, a varied crop rotation, inter-cropping of several different species of crops on one field and collection/storage of rainwater. Among the positive effects are increased yields, higher groundwater levels and increased self-determination for women. The Tigray Project is an example of how agriculture can be developed so that it is based on local knowledge and resources that ensure local circulation of plant nutrients, while at the same time favouring and enhancing ecosystem services and minimising the impact on the climate.

The UN Food and Agriculture Organisation (FAO) adopts the same theme in the report 'State of Food and Agriculture 2007', which recommends directing payments to farmers for the ecosystem services they provide. The FAO claims that this could be a good way of protecting the environment and doing something about the growing problems of climate change, declining biological diversity and lack of access to water.

'Pay farmers for supplying ecosystem services'

In the Tigray Project farmers receive direct 'payments' for their work in the form of increased yields and more services that contribute to increased welfare, for example fuel wood, honey and better access to drinking water. However, in the same way as growers today receive payment for wheat or coffee, they should also be paid for providing important ecosystem services, for example protection from flooding, water purification, maintenance of biological diversity or uptake of greenhouse gases. The FAO, like the Millennium Ecosystem Assessment, believes that one of the most important reasons for the environmental problems in agriculture is that a number of ecosystem services do not have any direct market value. Farmers therefore actually have no economic incentive to protect ecosystems or to use the services they provide in a sustainable way.

Today farmers receive payment for the amount of food, fibre or biofuel they produce, while the value of other ecosystem services that agriculture can produce is underestimated. A range of misguided subsidies also promote steadily accelerating productivity at the expense of ecosystem services, according to the FAO and the Millennium Ecosystem Assessment. The FAO suggests that the system of payments for ecosystem services could e.g. comprise direct payments from governments to producers or indirect payments through consumers paying extra for 'ecosystem services-producing' food in the same way that they currently pay extra for fair-traded or organic coffee.

A number of current global reports highlight the same point: future agriculture must be based more on biological diversity and ecosystem services than fossil fuel – which increasingly appears to be the only long-term sustainable alternative.

Composting decisive

A deciding factor in the success of the Tigray Project is composting. This involves the accumulation and proper arrangement/mixing of animal manure, crop residues, weeds and organic household waste in pits in the ground so that they can be broken down into compost, which is used as a soil conditioner. Researchers from the Institute for Sustainable Development (ISD) have shown that the yields from land where this compost fertiliser is used are greater than those from land on which artificial fertilisers are used. A number of other positive effects of compost use have also been identified, viz: increased biological diversity, decreased incidence of weeds (the seeds are killed when the compost heats up during the decomposition process), decreased vulnerability to drought (increased soil humus content increases water-holding capacity), higher resistance to pests and lower costs for farmers compared with buying artificial fertiliser.

Box 3: Millennium Ecosystem Assessment

The global UN study, the Millennium Ecosystem Assessment (MA), was carried out between 2000 and 2005. Over 1400 leading researchers and other experts from 95 countries took part in the study, which focused on the free services provided by nature that are of benefit to mankind. The results show that around 60 % of the ecosystem services studied are being destroyed or used in a non-sustainable way, for example air and water purification, pollination of crops, natural pest control, food, fibre, fish and wood, and the ability of the ecosystem to mitigate the effects of natural disasters.

According to the MA, the status of ecosystems world-wide is so badly deteriorated that this can have great negative consequences for attainment of the UN Millennium Development Goals (MDGs), which were adopted in 2001 and which include halving poverty and hunger in the world and securing access to clean drinking water. However, according to the future scenarios in the MA, the negative trends could be reversed, as we have the tools, policies and technology required to drastically decrease the losses of ecosystem services. This would involve, among other strategies, stopping the subsidies that lead to over-use of chemical pesticides and artificial fertilisers in agriculture, measures to mitigate the impacts of climate change, market mechanisms for setting a price on ecosystem services and investment in the sustainable management of important ecosystems.


a) Gebre Mikael combines honey production with farming. This strategy provides both honey and improved yields with the help of his bees. b) The use of compost is a pillar of the Tigray project. Photo: Jakob Lundberg

Portrait 2: Gebre Mikael, beekeeper and farmer

According to honey producers in the area, the benefit of the Tigray Project is that there are now plenty of herbs and bushes, which bees need to collect nectar and pollen. This, together with the introduction of new, modern and more high-yielding hives where the bees are helped to make cells and keep the brood and honey storage sections apart, has led to an increase in beekeeping according to Gebre Mikael, who specialises in honey production. He builds hives and rears swarms and even queens, which he sells to others. He was given the land where he has his beehives along a slope above the village by the local authority. Today he has 26 modern and five traditional beehives. Honey production is important in Ethiopia, both for farmers' household consumption and as a source of income in the local market. In recent years, the popular white honey from Tigray has also begun to be exported. Last but not least, honey production also contributes to increased pollination of crops and thereby generates an essential ecosystem service that increases yields in the area.

"Biodiversity is critical for our local food security"

Box 4: UN climate panel on agriculture and ecosystem services

In 2005, the UN Intergovernmental Panel on Climate Change (IPCC) produced its fourth major assessment of climate change. In this, the panel of experts reported that anthropogenic emissions of greenhouse gases have already had serious effects on the planet, for example more flooding, more extreme drought, displacement of animal species and melting glaciers. The IPCC also reported that the changes observed to date will become increasingly obvious, with considerable consequences for ecosystems, agriculture, food production and human health. If global warming continues, up to one-third of the world's plant and animal species will have died out by the end of this century. This is expected to lead to considerable negative effects on the capacity of ecosystems to supply goods and services to society.

Table 1: Summarising matrix with examples of some of the most important practices used in the Tigray Project and the ecosystem services promoted by the respective method. +++ = strongly promoted, ++ = medium effect, + = noticeable effect. The matrix has been developed together with Johanna Björklund, Swedish University of Agricultural Sciences.

	Practises									
	Installation of trench bunds and check dams to hold water and soil, and decrease gully formation	**Poly-culture / intercropping (growing several different crops on the same field)**	**Varied crop rotation (e.g. nitrogen fixing plants)**	**Composting**	**Planting of multi-functional trees**	**Restriction of free grazing and development of local community by-laws**	**Making ponds**	**Use and conservation of local plant varieties and landraces**	**Use of local herbs for medicines and for biological control of pest organisms**	**Raising seedlings of long season crops in nurseries**
Erosion prevention	+++			++	++	+++				
Recycling of nutrients		+++	+++	+++	+		+			
Biological nitrogen fixation		++	+++	+	+++			++	+	
Pollination		++	++		++			+	+++	
Weed and pest control		++	+++	++				++	++	
Buffer against flooding	+++			+		+	++			
Conservation of genetic diversity			++		++	+		+++	+	
Conservation of soil fertility		++	++	+++	+	+++				
Improvement of soil water-holding capacity	++	+	+	+++	+	+				
Ability to bind carbon (contribute to decreased greenhouse effect)		+	+	+++	++	++				
Effect on livelihood opportunities for farmers	Increased agricultural area, increased access to water	Larger and more stable yields, increased diversity of products	Larger and more stable yields, increased diversity of products	Larger yields, decreased water stress, improved soil quality, improved soil aeration under excess rain	Increased access to food, feed, fuel wood, improved adaptability, more milk from cows	Improved productivity and health in domestic animals, recovery of natural flora and fauna	Increased access to water for animals; prolonged growing season	Improved ability to adapt to variations in climate and environment	Higher yields and improved animal, crop and human health	Prolonged growing season, and improved human health

In the 1950s, plant breeders around the entire world used genes from Ethiopia's indigenous barley varieties in order to produce new varieties that were resistant to the notorious Yellow Dwarf Virus. Photo: Anneli Nordling

3. Diversification of crops and cropping methods

Biological diversity in agriculture is a way to spread the risks and decrease the cost of expensive inputs. Diversity of species also contributes important ecosystem services such as pollinating insects, natural pest control, water purification and maintenance of fertile soil.

Global biological diversity is decreasing rapidly, both in natural ecosystems and in agriculture, forestry and aquaculture. For example, today four species – rice, maize, wheat and potato – make up about half the energy intake of humans from the plant kingdom. In a similar way, almost half of global meat production comes from only a few breeds of pig, chicken and cattle. Furthermore, the richness of variation within the different species used in agriculture is declining. One example of this is the loss of rice varieties. Only a few decades ago, farmers in India grew 30 000 different varieties of rice, which were adapted to local conditions. Since the green revolution, these have been replaced by a few high-yielding rice varieties that are often grown in monoculture. This is leading to cropping systems with increased susceptibility to diseases, pests and climate change. To achieve profitability and continuing high yields there is often a need for a range of fossil fuel-consuming and environmentally damaging cultivation inputs such as poorly managed irrigation, pesticides and artificial fertilisers – items which poor farmers seldom can afford. One option is to 'leapfrog' this non-sustainable technical phase and increase productivity through a form of agriculture based on local knowledge, increased diversity and new information about ecosystem services.

Diversity a natural part of daily life in Tigray

In the Tigray area, diversity is a natural part of the daily life of farmers. Like most other poor farmers in the world, they do not rely solely on a few staple crops but spread their risks with the help of diversity in cultivation. They stimulate and exploit natural processes to maintain soil fertility and to counteract pest attacks on crops. For example, the farmers alternate crops on small fields where the same crop is not grown in neighbouring plots. They also grow different species together on the same field, that is, trees and bushes are mixed with different crops to prevent weeds, diseases and pests gaining a foothold.

Farmers in Tigray have their own seed, saved from plants that have given high yields in previous years. Many different types of seed are stored and farmers exchange, are given or buy at a low price from their neighbours if they run out of any type. How the varieties are mixed in the field depends on a range of factors, for example how soon the rainy season starts and the soil type. If the rains begin in May or early June, farmers can plant varieties of finger millet, maize or sorghum that give higher yields but that requires a longer growing season.

Nurseries for fruit trees like papaya and guava improve the livelihood of local people. In addition, crops that require a long growing season are pre-germinated together with multifunctional trees and shrubs. Multifunctional species are important for landscape conservation and the generation of ecosystem services. For example, trees in and around the fields create habitats for birds which prevent pest insect outbreaks. Photo: Jakob Lundberg

Box 5: Local ecological knowledge important in protecting indigenous plant varieties

As a rule, farmers in Tigray prefer local indigenous plant varieties to the modern cultivated types that are also available as seed on the market. This was confirmed in a study carried out by researchers from The Norwegian University of Life Sciences (UMB) in Ås, Norway. In Tigray there are a number of local varieties of barley (*Hordeum vulgare*) with wide genetic variation that have been developed over thousands of years through farmers opting to save seeds from mother plants that proved to grow well under the local environmental and climate conditions. Many of the modern varieties would in theory be able to grow better with more uniform access to water and fertiliser and if the crops were never attacked by pests or diseases. However, in the daily life of poor farmers, inputs such as irrigation, artificial fertiliser and crop protection chemicals are a rarity. These farmers therefore need the tolerant, locally bred varieties of plants, which are adapted to the local environment. Thus, it is important to maintain a decentralised selection process based on local ecological knowledge in order to preserve the genetic variation in the crop varieties grown.

Source: Fetien Abay Abera, 2007.

Box 6: Biological diversity – increasingly important in a changing climate

Biological diversity is the richness in variation within species, between species and of the ecosystems in the landscape. This diversity provides us with everything from food and clothes to medicines and shelter. There is also a direct link between biological diversity and the long-term capacity of ecosystems to supply ecosystem services such as air and water purification, pollination of crops and protection against erosion. Between 20 and 30 % of all plant and animal species risk becoming extinct if the mean global temperature increases by 1.5 to 2.5 degrees, according to the IPCC. This means that ecosystems will become more vulnerable and that their long-term ability to deal with changes in the climate and the environment (their resilience) will decrease. Diversity is also the foundation for plant and animal breeding and an insurance for the future. We know that climate and the environment will in all probability change at an increasing pace and it is therefore important to maintain a diversity of plants and animals with different environmental requirements that can perform the same functions under new conditions.

Teff, an indigenous grain from the highlands of northern Ethiopia, is important as a food crop in both Ethiopia and Eritrea. Teff is used mainly to make injera, a local variety of pancakes. Photo: Jakob Lundberg

Box 7: Rediscovered Ethiopian diversity saved world barley from disease

Ethiopia's biological diversity is not only of local significance but is also important for the global genetic diversity of the world's staple crops. One example was when Yellow Dwarf Virus (YDF) almost eradicated the globally important cereal barley during the 1950s. The solution was found in Ethiopia. YDF, which is transferred between different plants by an aphid vector, is a disease that can infect and damage wheat, barley, oats, rye, maize and rice. Plant breeders around the entire world used genes from Ethiopia's indigenous barley varieties in order to create new varieties that were resistant to the virus. This rescue operation is said e.g. to have saved California from yield losses of millions of dollars during the 1950s, without Ethiopia receiving a single cent in financial compensation. "I'm not saying it was unfair", says Tewolde Berhan Gebre Egziabher, "it happened a long time ago, before fairness in this regard became an issue".

In the case of sorghum, it is customary to grow several different varieties in the same field depending on the end use, for example beer, bread or snacks.

Plant nursery for multifunctional trees

Another way to promote diversity is to integrate multifunctional trees into the cropping system. These trees provide branches and leaves for animal feed and fuel and edible fruits and bark that can be used as medicine. They are also of benefit to birds, which keep pest insects under control, and to pollinators that can provide honey and increase the yields of e.g. coffee bushes, where the yields can be up to 50 % higher with the help of pollinators. Shade trees also protect crops from downpours, desiccation and wind and can provide extra income from timber and fruit (e.g. bananas, oranges, papaya, mulberries and limes). Another example is Sesbania, a tree that provides animal fodder and also improves soil fertility through binding atmospheric nitrogen with the help of bacteria living in symbiosis with its roots.

In 2004, the ISD set up a plant nursery for different trees which are sold at cost price to farmers. In three years, around 50 000 fruit and forage tree plants have been produced and distributed to farmers.

a) Abaddi, one of the so-called innovative farmers in the Tigray project, showing one of the channels in his irrigation system. Thanks to this system, he can now get an extra irrigated harvest each year. b) Sesbania, a multifunctional tree, which provides both fodder, shade, and improves soil fertility through biological nitrogen fixation. In this Sesbania, in the midst of Abaddi's fields, weaver birds have built their nest. Photo: Jakob Lundberg and Anneli Nordling

Portrait 3: Abaddi Kelkay, farmer

Abaddi was one of the innovative farmers who took part in the Tigray Project. He began building up his farm five years ago on land that by others was considered to be worthless. Over time, he has created an ingenious irrigation system for his crops that includes irrigation dams and a system of irrigation channels. The use of compost is another reason behind his success. For example, his maize yields are considerably higher than those of his neighbours. In addition, water flows all the year round thanks to the farmers cooperating to dam the water upstream and allow it to infiltrate the soil. Overall, this has led to Abaddi now having a second irrigated crop in the spring (compared with the former single rain-fed crop in the autumn). Intensive and prolonged work to create fertile soil together with active management of water resources has resulted in a doubling of his income. Now he and his wife are well able to feed the nine members of their household.

Reasons behind the wide genetic variation in the crop varieties grown in Ethiopia

- Long farming tradition (~ 5000 years) which has provided the opportunity for varietal differences to develop
- Rapid and wide variations in climatic conditions, soil texture and ecological conditions in mountainous regions
- Many different ethnic groups with little mixing, all working with different breeding and cropping methods
- Limited industrial agriculture, little centralized plant breeding

Box 8: Resilience – the ability of a system to handle change

Resilience is the long-term capacity of a system to deal with change and continue to develop. For an ecosystem such as a forest, this can involve dealing with storms, fires and pollution, while for a society it involves an ability to deal with political uncertainty or natural disasters in a way that is sustainable in the long-term. For an agricultural system, resilience involves an ability to deal with everything from climate change and pest attacks to changes in agricultural policy.

Resilience therefore comprises the ability of systems to withstand stress and to restore essential functions afterwards. In the long term this requires an ability to adapt and self-renew.

Increased knowledge of how we can strengthen resilience in society and nature is becoming increasingly important in coping with the stresses caused by climate change and other environmental impacts.

Thanks to the Tigray project's success in restoring the landscape upstream, there is now water flow all year round in streams that were previously-dried-up over a large part of the year. Photo: Jakob Lundberg

4. Water management in a landscape perspective

Water is a basic essential for human life and for the pursuit of farming. However, securing access to water is becoming an increasingly difficult challenge due to population growth, non-sustainable use of resources and a more unpredictable climate. In the Tigray Project, the aim is to meet these challenges with a holistic approach that integrates improved water management, erosion control and soil improvement in a landscape perspective. Overall, the programme of measures within the project to prevent soil erosion and improve water management has led to the restoration of water flow in dried-up streams, rehabilitation of arable land and increased yields.

One of the greatest obstacles to reaching the Millennium Development Goal of halving the widespread malnutrition in the world by 2015 is the increasing lack of water. The decline in flows and groundwater reserves in irrigation-dependent regions is placing new emphasis on the role of rain-fed agriculture, which has been shown to be important in bridging dry periods and is thus a key strategy in adaptation to future climate change.

In Tigray the rainy period occurs from the end of June to the middle of September, and, as a rule, heavy rains fall during a relatively short time. On average around 500-700 mm fall in the highlands, while eastern regions receive only around 200 mm. In order to secure access to water and food production in the region, there is a need to collect water in various ways and save it for dry periods, a process known as *water harvesting*.

Forest clearing to obtain fuel and building materials, overgrazing and trampling, expansion of agricultural land and in later years urbanisation have led to the disappearance of a large proportion of indigenous forest and cultivatable land. In combination with this non-sustainable use of resources, vital rainfall ironically poses a threat to the entire landscape. During the rainy season, the lack of forest and other vegetation leads to severe soil erosion so that gullies are formed and cut through the landscape, washing away the fertile topsoil.

In order to counteract rapid losses of water and soil, the Tigray Project developed a toolbox of effective low-technology solutions. Local farmers were then encouraged to choose the methods they thought were most relevant for their needs, an approach which led to a range of different solutions being put into use in different local communities. By then scaling up of the most successful experiences, an important adaptation and learning process that was critical for the success of the project, was initiated. The solutions, which were all aimed at decreasing soil erosion and improving

a-c) A number of methods to conserve rain water have spread throughout Tigray with the help of innovative farmers. d) The priest Malede Abreha began digging his first well in 1988 to remedy the drought and famine. At first he extracted water with the help of ropes and buckets, but over the years, he has developed a series of inventions to irrigate his crops. The first was a lever, but he now uses an invention adapted from one seen in an exhibition in Mekele. His methods have inspired a number of other farmers in the area. Photo: Hailu Araya, Anneli Nordling and Jakob Lundberg

Box 9: The art of making better use of water and soil resources

Within the Tigray Project, a holistic perspective of the landscape stimulates a range of measures for decreasing soil erosion and improving water management, for example:

- Making trench bunds, drainage ditches and construction of upstream dams to reduce the rate of water flow and decrease soil erosion during the rainy period. Soil is deposited in and between each construction and, combined with planting of indigenous tree and grass species, this has proven to be an effective method for restoration of gullies, and holding bunds in place between fields.
- Restriction of grazing from sensitive slopes (leads to regrowth of vegetation, which binds the topsoil, slows down water flow, improves infiltration and helps recharge aquifers).
- Composting, which improves the water-holding capacity of the root zone and make crops better able to survive droughts and floods (compost makes the soil more porous allowing more air to pass through to the root zone in wet periods and hold more water in dry periods).
- A number of methods for collecting rainwater developed by innovative farmers have been identified. This, together with making of ponds and establishment of small dams, ditches and channels, means that access to water can be secured throughout the year, while at the same time decreasing soil erosion.
- Transfer of knowledge and spread of low-technology water solutions such as rainwater harvesting from farmer to farmer.
- Allowing the regeneration of indigenous plants and trees along the slopes of the catchment areas.
- The focus of the Tigray Project has particularly encouraged women to pre-germinate, in a plant nursery, those crops that require a long growing period (4-5 months), for example finger millet and sorghum. The plants are then transplanted to the field when the main rainy season of around 3 months begins. Without the production of seedlings in a nursery, these long-season crops disappear from the cropping system.

The farmer couple Hawariya Berihe and Woldu Gebrewahid: "We had the worst soil and the least opportunity to succeed. We had to dig several dams and wells before we found water. We have worked hard, but succeeded in the end! If we could make it, anyone can!
Photo: Jakob Lundberg

access to water in the catchment areas, work across several different levels of scale, ranging from small drip irrigation devices with gourds to large-scale landscape management with ponds, dams and channels dug out and lined to hold harvested water. Through working in an introductory phase with innovative farmers, who distinguished themselves by being particularly interested in testing and developing new water harvesting and management methods, the techniques were effectively transmitted in the area.

Each group of farmers sharing a common water source also has a water guardian or 'father', who acts as chairman and helps the farmers organize themselves for the use of their shared water resource. The ISD acts as a catalyst in this regard in supporting and promoting innovator farmers e.g. for the excavation of wells, and installation of ponds and irrigation systems. This has resulted in increased access to water, while the protection of the catchment areas has recharged aquifers and raised the groundwater levels. In a number of areas, springs, streams and rivers that had previously run dry for long periods now contain water all year round. One result of this positive development is that it is now possible to produce an extra irrigated spring crop as an important complement to the former single rain-fed autumn crop. The other outcome is the increasing numbers of fruit trees being planted by farmers, particularly women. The outcome of this and other measures (see box 9) is that farmers in the project have more than doubled their income, which has improved living conditions dramatically as regards to both food security and household finances.

A subsequent step that many local farmers are hoping for is to be able to process their agricultural produce and gain access to new markets, so that they can receive better payments for their increased yields.

Portrait 4: Woldu and his wife Hawariya. From gully to diversity farming

After a period as a town dweller, Woldu recognised that there was no chance of him providing his family with a good life in the town. He was offered a piece of land in a gully by the authorities and accepted it simply with the idea of keeping a few animals there. During the rainy season the soil along the slopes was previously washed away, but Woldu had seen how the farmers in the neighbouring community involved in the Tigray Project had managed to prevent erosion in the gully on the other side of the hill and he decided to do the same on his land. He began by building stone walls and ditches above his crop land as protection against water erosion. He then transported soil using a wheelbarrow and spade he received from the ISD and was eventually able to refill the gully.

There is still a constant ongoing battle to prevent all the soil being washed down the valley. According to Woldu, the walls and ditches have to be repaired after every rainy season. Today the couple use no chemical pesticides, but Hawariya makes her own biological crop protection mixture and herbal medicine to improve their income. Woldu has also managed to dig a six-metre deep well by hand and this provides sufficient water for the household and the fields throughout the year. Today, after 6-7 years of work, they grow e.g. oranges, limes, papaya, mulberry and bananas using seedlings from the local plant nursery, which is supported by the ISD. Their family can live quite a good life off the land. Woldu adds "I'm still amazed by what it [the area] became".

Farmers in a meeting in Wkro. Photo: Hillevi Rundström

5. Women's livelihood – a key to success

The Tigray Project with its emphasis on sustainable development and ecological soil management has resulted in a range of improvements for poor farmers in general and for the poorest women-headed households in particular. A key factor behind the successes of the project is the role of women. In the region, there is a disproportionately large number of families for whom single mothers are the sole provider. This is a result of the many years of war in Ethiopia, in which large numbers of men have lost their lives.

Being poor, female and a farmer brings a host of problems, e.g. because women by tradition are not allowed to plough the fields or work with pack animals. Those women who no longer have any male relative must seek the help of some other man, often after he has finished ploughing his own fields, so the women suffer from a delayed and shortened growing period. This system is known as 'share cropping' and involves part of the harvest going to the man who helped with the ploughing. The Tigray Project has therefore focused on enhancing the position of women in the communities and has specifically encouraged them to pre-germinate in a plant nursery those crops that require a long growing season, for example finger millet, sorghum and maize. These plants are then transplanted outdoors when the rainy season begins, as opposed to sowing seeds directly in the field, which would require a much longer growing period. This is also beneficial from another perspective: climate change has meant that the rainy season is becoming more unpredictable.

In addition to this support for single mothers, the project has also trained unemployed young women, provided seeds and seedlings for plant nurseries, arranged study trips and promoted the use of simple technical solutions such as foot pumps. By encouraging women to buy sheep, goats and cows or to begin beekeeping, the project is also contributing to making women self-sufficient and independent of their male neighbours. It has also emerged that women are often the better credit holders, not least as regards microcredits, which in recent years have been highlighted as a successful path to economic and social development for the poor in rural areas in many parts of the developing world.

Those responsible for the Tigray Project have also identified a number of other difficulties that single mothers can encounter. For example, these women have not the same strength to dig wells as men, they have more difficulties in getting rid of porcupines (a major pest) and they do not have the same market information as men because they work in the home and take care of children, while men have more contact with the outside world. Women are also restricted in terms of transport since, according to tradition, pack animals can only be loaded/unloaded by men.

The women in the Tigray area have a more central role than the men as regards certain knowledge on, and protec-

a) Lychee fruits b) Yeshi, a farmer and widow, cultivates e.g. garlic, spices, fruit and teff. She has been helped by plants from the ISD. She wants to continue to work on the farm, improve her drainage and irrigation, and plant more trees. c) A woman in Aksum.
Photo: Anneli Nordling

tion of, biological diversity. They often have the main responsibility for preserving local varieties, crops and breeds. In Tigray, thousands of different varieties of barley, durum wheat, sorghum and teff are grown. A number of genetically distinct variants of each crop are often grown on the same field. In other words, this is a living gene bank for which farmers are important because they are custodians of the genetic diversity and continuously adapt and improve the varieties through their selection of seed.

Most farmers in the world are actually poor women and even though women's rights are mentioned as far back as 1992 in the Convention on Biological Diversity, much more must be done to ensure that they are involved in decisions concerning the preservation, sustainable use and equitable allocation of the benefits of biological diversity, e.g. ecosystem services.

Box 10: Role of women for the environment, agriculture and in combating poverty

The poor women of the world play a key role in agriculture, resource management and maintenance of natural assets. International and national strategies for combating poverty, agricultural development and sustainable development should therefore be based on a gender-aware analysis. The majority of the world's 1.3 billion poorest people, who live on less than one American dollar per day, are women. These poor women often live in close proximity with – and have extensive knowledge of – their surrounding ecosystem since they have the main responsibility for growing crops and fetching fuel, food and other raw materials from nature. Despite this, very few women from poor countries are included in an official context where strategies for resource management are discussed and where decisions are taken on resource allocation.

However, change is on the way. International negotiations on the environment, agriculture and development are focusing increasingly on the gender issue. More people are recognising that discrimination counteracts efforts to combat poverty and achieve sustainable development. In 2003 the UN Committee on Sustainable Development decided that equality should be taken into consideration in all areas by the year 2015, when the work of achieving the Millennium Development Goals should have realised its various objectives.

a) Papaya flowers b) Mama Yohannesu in her orchard in the Adi Nefas. Photo: Anneli Nordling and Jakob Lundberg

Portrait 5: Mama Yohannesu

Mama Yohannesu lives with one unmarried female relative. She has a fruit orchard that she set up by herself without any contact with the Institute for Sustainable Development (ISD). Previously she had problems with animals coming in and destroying her plants, but now she has a little fenced-off orchard with a variety of plants. Today, a number of her plants come from the plant nursery set up by the ISD and she has also received help to make her well and fencing from the local authority and the ISD. Mama Yohannesu mainly grows Citron, a large type of citrus fruit that is believed to be good e.g. for the stomach and heart, which she can harvest throughout the year. The orchard produces good yields and provides her with sufficient income to support herself. She also produces young plants by layering to sell and give to her neighbours.

A workshop in Wkro with farmers to display how the management of their catchment area has dramatically improved the situation for cultivation, for example by reducing soil erosion. The availability of feed for animals has also improved and access to food has increased, much thanks to the compost, which made the land fertile and reduced expenditure on fertilizers. Photo: Jakob Lundberg

6. Conclusions

- There is a need for a comprehensive change of course within agriculture in order to reach the international targets on eradicating poverty and decreasing hunger in a sustainable way. Future agriculture must be based more on biological diversity and ecosystem services than on fossil fuel.
- The Tigray project in northern Ethiopia is a successful example showing how farmers, researchers, local advisors and agricultural experts can together devise a system based on local inputs, biological diversity and ecosystem services. A key factor has been the active participation of farmers, who were allowed to choose and adapt the different cultivation methods to their local conditions.
- The project has produced a range of positive results such as higher yields, higher groundwater levels, better soil fertility, decreased susceptibility to drought, increased income and better opportunities for women to make a living.
- The Ethiopian government has adopted the approach used in the Tigray project to prevent soil destruction and combat poverty in 165 different districts in the grain-producing regions of the country. A holistic approach that integrates improved water management, control of erosion and soil improvement is now being used in a landscape perspective.
- Climate change already poses a great threat to global food security. Large parts of Africa that are already severely affected risk suffering further hunger and malnutrition, according to the UN panel on Climate Change.
- Increasing amounts of food will be needed in Africa in the future, while the use of fossil fuel – which forms the basis of today's intensive agriculture – must be decreased due to climate change and rising oil prices.
- An appropriately designed form of agriculture based on ecosystem services can decrease the need for fossil fuels and also decrease the vulnerability to climate change.
- The poor women of the world play a key role in agriculture, resource management and conservation of various natural resources.


a) Finger millet is an important crop in Tigray. b) Young woman in Tigray. Photo: Anneli Nordling and Jakob Lundberg

7. Recommendations

- International aid, research and education must be directed more towards decreasing agriculture's net emissions of greenhouse gases and adapting farming systems so that they can cope with future climate change.
- National strategies for agricultural development and combating poverty must focus more on support for small farmers and projects to develop farming systems based on ecosystem services.
- Different systems for compensating farmers for production of ecosystem services should be investigated and developed, so that these are of greater benefit to poor farmers in developing countries.
- Support within the agricultural sector should be directed more towards spreading risk and improving adaptive capacity. This can be achieved by promoting diversity-based agriculture that uses local varieties, crops and breeds – with characteristics such as tolerance to drought and heat – and by promoting a diversity of cultivation systems.
- International and national strategies for combating poverty, agricultural development and sustainable development must increasingly be based on a gender-aware analysis.
- Support for farming organisations and voluntary organisations within the environmental, agricultural and food sectors must be intensified, particularly with regard to policy development, cooperation, networking and farmer field schools.
- Specific support must be provided to help poor small farmers sell their surpluses and process their products, so that they are able to access the market more easily.
- More support should be given to local advisory centres, development projects and demonstration activities within the areas of organic production, small-scale food processing and environmental technology.
- The use of rain in rain-fed agriculture must be improved through investment in small-scale systems for collection and storage of rainwater (water harvesting).
- More funding should be provided for research into ecosystem services, resilience and sustainable production methods in agriculture. Cross-disciplinary and participatory research should be particularly supported.

Box 11: Nine positive results from the Tigray Project

1. Increased productivity and increased yields
2. Decreased susceptibility to drought, pests and flooding
3. Decreased dependence on the use of fossil fuel
4. Higher groundwater levels
5. Increased soil fertility and soil more resilient to erosion
6. Rehabilitation of damaged land
7. Increased income
8. Improved livelihood opportunities for women
9. Increased biological diversity and promoted production of ecosystem services

8. Sources and further reading

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This report is based around agriculture in Tigray, northern Ethiopia. The area has long had severe problems with soil erosion and recurring periods of drought, but farmers in a number of villages have succeeded in reversing the negative trend towards one of increasing yields and better living conditions. The local population in the villages have developed new irrigation methods, prevented erosion and have begun to use compost. These new methods have been developed in collaboration with local authorities, universities and the environmental organisation ISD (Institute for Sustainable Development). Today farmers in the area are practising a form of agriculture which in many ways makes use of the ecosystem services that exist in the area and which contributes to conserving these services. The methods are now being implemented in several other regions throughout the country.

The Swedish Society for Nature Conservation is collaborating with ISD. We have established an exchange of information between our organisations and are working together for sustainable agriculture. The Swedish Society for Nature Conservation also provides financial support to ISD. In addition, the Swedish Society for Nature Conservation is collaborating with many other farming organisations in the developing world and with organisations working on issues concerning forests, coasts and seas, climate, chemicals, trade and food security. In total, the Swedish Society for Nature Conservation is working with around 60 organisations in over 20 different countries. The work is largely funded by Sida (Swedish International Development Cooperation Agency).

Swedish Society for Nature Conservation

Naturskyddsföreningen. Box 4625, 116 91 Stockholm, Sweden

Phone + 46 8 702 65 00. info@naturskyddsforeningen.se

The Swedish Society for Nature Conservation is an environmental organisation with power to bring about change. We spread knowledge, map environmental threats, create solutions, and influence politicians and public authorities, at both national and international levels. Moreover, we are behind one of the world's most challenging ecolabellings,"Bra Miljöval"(Good Environmental Choice).

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