SOME EXAMPLES OF BEST PRACTICES BY SMALLHOLDER FARMERS IN ETHIOPIA

Book Three

Developed by
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Addis Ababa, Ethiopia

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CONTENTS

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BPA, PELUM Ethiopia, and PROLINNOVA Ethiopia
Addis Ababa, Ethiopia

Foreword

This is the third book on stories of grass-roots change by farmers, for farmers. This timely publication shares locally available and successful practices in the smallholder farming system. The practices documented here demonstrate the innovative capacity of Ethiopian farmers, and the book aims to share the valuable indigenous knowledge and innovation to a wider audience. The book is meant to inspire farmers, researchers and development practitioners and develop, test and adopt innovative technologies. Farmers themselves can share the experience, while research and development organisations can also use the information to formulate agricultural development strategies and policies which strive for sustainable development.

A firm supporter and promoter of sustainable agricultural development, the Best Practice Association believes that knowledge such as is contained in this book can go a long way to advancing Ethiopia's economic development. Some of the stories herein explore the coping strategies of farmers to the effects of climate change, while others look at seed security and farm diversification options such as agroforestry, human nutrition (such as the *Moringa oleifera* tree), ecological farming, and innovations such as expanding vegetation cover and animal feed.

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Steffen Schulz
Integrated Soil Fertility Management Project / GIZ
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Abbreviations

ABN	African Biodiversity Network
BPA	Best Practice Association
CEC	Cation Exchange Capacity
CRGE	Climate-resilient green economy
FAO	Food and Agricultural Organization of the United Nations
FFS	Farmer Field School
FTC	Farmer Training Center
GIZ	Deutsche Gesellschaft fuer Internationale Zusammenarbeit
IPM	Integrated pest management
ISD	Institute for Sustainable Development
NPK	Nitrogen, phosphorus and potassium
PAN-Ethiopia	Pesticide Action Nexus Ethiopia
PE	Prolinnova-Ethiopia
PELUM	Participatory ecological land-use management
SMS	Short message service
SNNPR	Southern Nations, Nationalities and Peoples Region

EXAMPLES OF BEST PRACTICES BY SMALLHOLDER FARMERS IN ETHIOPIA

1. INTRODUCTION

1.1 THE AIM OF THE BOOK

This book collects together some of the many stories of best practices by smallholder farmers. The practices have emerged from within and alongside projects focused on solving problems of natural-resource management, crop and livestock production and food security. The book aims:

(i) to document good practices and appropriate technologies which positively impact food security and sustainable development;
(ii) to create a networking platform for organisations and individuals.

The book avails best practices to development partners, local experts, researchers and other professionals, encouraging them to understand and incorporate the practices into their development undertakings and research programmes. The innovations have been developed locally by farmers. They are being promoted as part of wider interventions by members of the PELUM Ethiopia Consortium, namely the Institute for Sustainable Development (ISD), the Best Practice Association (BPA), Pesticide Action Nexus Ethiopia (PAN-E), PROLINNOVA–Ethiopia (PE) and projects supported by the Church of Sweden.

The Best Practice Association was founded in November 2011 to assess, document, promote and scale up best practices developed by farmers. The BPA also builds awareness among agricultural specialists, researchers, academicians, policymakers and other stakeholders in Ethiopia about the effectiveness of local practices and livelihood innovations.

Chapter 1 of this publication provides general background on the context; Chapter 2 highlights options of ecological farming in terms of organic cotton production, urine as fertiliser, converting parthenium weed into compost, and the multifunctionality of biogas. Chapter 3 explores options for farm diversification, with a focus on agro-forestry and human nutrition from the *Moringa oleifera* plant. Chapter 4 looks at farming innovations such as growing *Momona* and *Shibaka* from cuttings, fruit harvesting, goat and/or sheep breeding, and documentation and information dissemination by farmers. Chapter 5 considers seed security for food security as a basis for farming systems; Chapter 6 explores issues related to climate change, including providing a case of Tigray Region. A summary of the experiences shared and learning programme conducted in December 2014 in Hawassa is presented in the annexes.

1.2 Environmental and Political Challenges Facing Farmers

Land degradation, climate change, drought leading to famine and war have all played large parts in recent Ethiopian history. In spite of this, provision of agricultural- and health-extension support services is as widespread as it has ever been, a trend which has been reflected in overall improvements in agricultural production and productivity as well as the government's attention to integrated environmental conservation, the Climate Resilience Green Economy (CRGE) and Climate-Smart Agricultural policy.

One critical issue in Ethiopia remains the challenge of sustainable market access. Exemplary efforts of individual farmers to overcome the challenge, mostly by diversifying their farm products throughout the year, are profiled in this document.

1.3 SELECTING BEST PRACTICES

The best practices described here were chosen following the third study visit, organised with the support of the Church of Sweden, to Hawassa, Wondo Genet, Arsi and Mojo. The aim of the visit was to provide opportunities for participants to discuss and learn from local experience in sustainable agricultural practices across southern Ethiopia. Focus was given to discussion around soil fertility, small-scale irrigation, soil and water conservation, crop diversification, biogas and bio-slurry, agro-forestry and beekeeping. Participants exchanged experiences in study groups and with local farmers; it is hoped that they will go on to integrate new practices learned on their farms and within their projects, as well as sharing beneficial knowledge with those around them.

2. OPTIONS FOR ECOLOGICAL FARMING

2.1 Integrated Pest Management for Cotton Farmers in Arba Minch

by Atalo Belay, Tadesse Amera and Zemenu Genet (PAN-Ethiopia)

2.1.1 Introduction

In southern Ethiopia cotton is grown by smallholder as well as large commercial farmers. The crop, however, suffers attacks by a wide range of pests such as bollworms (*Helicoverpa*) and sucking pests. The growers have to manage these pests effectively if they are to increase yields and profits.

Both smallholder and commercial cotton farmers rely on synthetic insecticides to control pests throughout the growing season. Farmers use various pesticides including organophosphates, carbamates and organochlorins. The negative impacts of synthetic pesticides on human and environmental health underlie growing concerns over the unsustainability of long-term reliance on these chemicals. The risks posed by them are aggravated by the limited knowledge of cotton farmers on the responsible use of pesticide in general, as well as the lack of appropriate and easily accessible alternatives. Unless alternative pest-management options are introduced, farmers' dependence on synthetic pesticides will continue to aggravate the loss of biodiversity and damage to ecosystems and human health. On the positive side, there have been some encouraging results in the development of alternative pest-management options in cotton production such as the use of beneficial insects. This has attracted the attention of farmers and government departments.

2.1.2 Integrated Pest Management Comes to Arba Minch

The Arba Minch area is the second largest cotton-growing region in the country after Amhara Region. Smallholder and state cotton farms are located on the western side of Lakes Abaya and Chamo. The Arba Minch area is also rich in biodiversity, with 37 species of mammals and 188 species of birds in its Nechisar National Park, which lies between the two lakes. There are also many species of freshwater fish found in both lakes; however, they are both being polluted by agrochemicals applied by small aircraft to the cotton grown in the area.

An Integrated Pest Management[1] Farmer Field School (IPM-FFS) designated to cotton was first introduced to the area by UN-FAO in 2006. It lasted for only one year. Since then, PAN-Ethiopia has been following up with the trained farmers. In 2013, PAN-Ethiopia was granted a three-year project to upscale and expand the cotton IPM-FFS in Arba Minch Zuria and Mirab Abaya Districts of Gamogofa Zone, mobilising smallholder farmers to produce cotton more sustainably. The project lasted from January 2013 to December 2015, but, its extension and scale-up for a further three to five years is underway. The project involved more than 2,000 smallholder farmers in nine villages (Shelle Mella, Chano Mille, Zeyse Elgo, Kolla Shelle, Kolla Shara, Genta Kanchama, Faragossa, Kolla Mulato and Kolla Barena) in Gamogofa Zone. A variety of alternative pest-management methods were introduced, including a new technique called food spray, invented in Australia and piloted in Benin.

2.1.3 The Process

The main intervention method used to implement the IPM-FSS project was to train smallholder cotton farmers, large commercial

[1] Integrated Pest Management (IPM) follows ecologically sound approaches.

farm plant protection experts and local agricultural extension agents in IPM. Demonstration plots were set up at each of the project sites, at which the farmers to replicate what they had learned from the training. The IPM-FFS sessions were given at each project site for three hours, once a week. The main topics covered included pesticide health monitoring, preparation and application of food sprays[2], pest and beneficial insect scouting, agronomic practices and recording information about the farm, activities conducted and decisions made during the FFS sessions.

Figure 1: Training of farmers on beat sheet counting

Farmer Field Schools (FFS): A farmer field school is a group-based learning methodology. It comprises a group of smallholder farmers who live in the same village and share the same ecological settings and socio-economic situations. It is a 'school without walls', used to train farmers about plant protection and agronomic practices which will help them to increase their crop production sustainably. FFS also aim to improve the decision-making capacity of farming communities and stimulate the use of local innovation and

[2] Food spray is a supplementary spray applied to cotton farms to attract and conserve natural enemies into the sprayed field. It is an IPM ingredient made of food item.

indigenous knowledge in sustainable agriculture. FFS pursue processes of self-discovery and participatory learning, through which all of the farmers participate in agro-ecosystem data collection. Their main purpose is to provide an opportunity for farmers to develop habits of 'learning by doing'.

FFS attendees learn techniques like insect scouting and how to make food sprays. Insect scouting is carried out using the beat-sheet counting method. Beat-sheet counting is done by placing a white sheet on the ground beside a selection of plants. The cotton plants are lightly beaten so that insects fall onto the white sheet. The pests and natural enemies that fall on the sheet or fly during the beating are also counted and recorded. Beat-sheet counting of pests and natural enemies has to be done in the morning from 8.00 to 10.00 a.m. as this is when insects are less active and can more easily be found on the cotton leaves. Following the results of scouting, a decision regarding whether to apply food sprays is made. Food spray is applied whenever the ratio of natural enemies to pests is below 1:2. The components of the food spray / IPM materials are locally available, low cost and non-toxic; they include brewer's yeast, neem seed extract and maize.

2.1.4 Gains from the Project

- ***Farmers can identify pests and beneficial insects***

The farmers involved in the IPM-FFS training are now able to identify the main pests and beneficial insects. They also know which natural enemies feed on which type of pests. This enables them to make better decisions when they see insects in their cotton fields. Previously, farmers assumed that all insects on their crops were pests. Now they know how natural enemies help to maintain balance in their fields.

- ***Farmers have stopped using pesticides for cotton production***

The awareness of cotton-producing farmers about the importance of sustainable cotton production and about the negative human health and environmental impacts of pesticides has been raised via the training and demonstration sessions. The perception of farmers towards insects has changed as they now have an understanding of which insects attack their crops. They also do insect scouting and monitor the ratio between pest and natural enemy populations. They use food sprays if the ratio goes higher than the acceptable level. Food sprays attract natural enemies to the field before it is infested by pests. The natural enemies eat the pests at different stages of their life cycles. In this way the farmers have stopped using toxic pesticides for cotton production; some are even moving towards organic cotton certification.

Figure 2: Clean cotton produced organically

- ***Organic cotton producer cooperatives established***

The cotton producer cooperatives that have been established are linked to better markets, with support of the zonal cooperatives and the marketing departments. For example, *Shelle Mella Organic Cotton Producers' Association* grows organic cotton and is in the process of getting international organic certification, which will help them to market their produce more effectively both nationally and internationally.

- ***Higher incomes***

PAN-Ethiopia conducted a baseline survey on conventional cotton producers in January 2013, before the IPM-FFS project begins. It found that the yield of seed cotton for conventional smallholder cotton growers was 8-10 quintals[3] per hectare. After one year of IPM intervention, the yield of the IPM-FFS farmers was 18-23 quintals per hectare; for the 2014 season it had risen to 30-36 quintals per hectare - more than triple than at baseline.

Cotton marketing had previously been a challenge for the farmers, as they were getting low prices from the local middlemen (brokers). The price of seed cotton was 10 Ethiopian Birr (ETB) per kg in 2013, but it increased to 16 ETB[4] per kg in 2014. This price increment was because of the establishment of the cooperative mentioned above. It helped the farmers get organised and avoided the interference of the middlemen.

- ***Women's cotton-spinning associations***

As hand spinning is one of the common ways to make traditional clothes in Ethiopia, PAN-Ethiopia organised women cotton farmers in the project sites of Shelle Mella, Chano Mille and Faragossa into

[3] 1 quintal is equivalent to 100kg.
[4] 1 USD was equivalent to 20 Ethiopian Birr (ETB) in 2014.

women's cotton-spinning associations. These associations are now linked to local traditional cloth weaving micro-enterprises so that they can easily sell their hand-spun yarn through them. This was an essential step forward for women farmers to be able to generate their own income.

2.1.5 Moving Ahead

The project was implemented with local stakeholders, national and regional agricultural offices and other NGOs. Governmental agricultural extension agents, plant-protection experts and agriculture-office experts were involved in all the IPM-FFS training sessions, as well as the food-spray preparation and application. The involvement of local stakeholders, especially agricultural extension agents working at the grassroots level with farmers, has been vital in expanding the technology and practices to new areas.

The organic cotton producers' cooperatives and the women's spinning associations are important value-chain outlets which empower farmers to sustainably earn their own incomes. At the same time, farmers have reduced their production costs by avoiding the use of synthetic pesticides, which were more expensive than the food sprays. These benefits are important steps toward sustainable IPM-FFS.

"Pests should be called 'farmers' enemies' because they damage our crops, and natural enemies (beneficial insects) should be called 'farmers' friends' because they protect our field from farmers' enemies."

Menza Maile, a cotton farmer in Chano Mille, Arba Minch.

2.1.6 Successes

- Their cooperative has received a loan from a sister cooperative, which has aided it to collect cotton from farmers.

- The Gamogofa Zone Marketing and Cooperatives Department was supportive at every stage of the cooperative establishment and development.
- The cooperative has been granted land for warehouse construction by the local administration.
- The cooperative has signed agreements with Amibara Ginning Factory and Arba Minch Textile Factory in order to get ginning services and to sell lint cotton respectively.
- The cooperative now has links with the local textile factory.
- More farmers are now registering as members of the cooperative.
- Purchasing seed cotton carries a relatively higher price than that of local merchants buying from smallholder farmers. This is an encouraging move to initiate farmers to grow cotton and even to sell their product to the cooperative.

2.1.7 Challenges

- Farmers have a perception that they can't find farmers who are experienced in administrative and financial management.

Local merchants are trying to intervene by telling the farmers that the cooperative will no longer be strong, and so not to waste their time and money. This is because the merchants will no longer get cotton by the price they want once the farmers are organized and are better linked to markets.

2.2 Urine as Fertiliser

by Hailu Araya and Gebreyesus Tesfay

2.2.1 Introduction

Urine is a liquid by-product of humans and animals which is secreted from the kidneys. About 95% of the 0.8-1.5L of urine each person produces per day is water, while 5% is comprised of the macro-nutrients nitrogen (N), phosphorous (P) and potassium (K), as well as some trace micro-nutrients. This 5% has an NPK ratio of 11 : 1 : 2.5. In other words, urine is a fertiliser high in nitrogen, low in phosphorus, and moderate in potassium. Fresh urine has a pH anywhere from 5 to 9 depending on a person's diet, but it tends to move toward neutral as it ages and breaks down when applied outside.

The average person produces about 3.5kg of nitrogen, 0.5kg phosphorus, 1.0kg potassium, 0.5kg sulfur, 40g magnesium and 100g calcium per year. A family of four can produce the equivalent of a 50kg bag of NPK fertiliser from urine alone in a year.

The major components in urine are high nitrogen chemicals including urea, creatine, ammonia, and uric acid. Urine also contains a significant amount of salt (sodium chloride) and small quantities of calcium, magnesium and sulfur. Fresh urine is therefore an excellent high-nitrogen liquid fertiliser and compost accelerator, showing higher nitrogen content and lower P/N and K/N ratios than many mineral fertilisers. Another positive effect of using urine is that the phosphorous is in a plant friendly form, requiring no additional processing before it can be absorbed.

2.2.2 Preparation, Use and Application of Urine

Urine can be used as:

- **Natural fertiliser,** as urine is composed of macro- and micro-nutrients. It is an optimal fertiliser for plants during their vegetative stage of growth.
- **Compost accelerator:** Urine boosts bacterial colonies by adding much needed nitrogen. The regular addition of urine to compost piles keeps them healthy and hot.
- **Direct application to mulch** for farmers who thickly mulch their woody perennials, cane fruit and fruit trees with a high-carbon material like leaves or woodchips.

Preparing urine fertiliser by diluting it varies from crop to crop. For example, for lawns, trees, bushes and compost piles, urine only needs to be diluted one part of urine to five parts of water. For crops such as tomatoes, peppers and eggplant, and leafy crops like cabbage, broccoli, spinach, lettuce, as well as seedlings and new transplants, one part urine to fifteen parts of water is preferable. Greater dilution or 20:1 or more is appropriate for more tender plants, seedlings and potted plants which are more susceptible to salt build-up.

2.2.3 Effects of Urine

The effects of urine on all types of crop, vegetable and fruit tree are very impressive. After diluting the urine with water it is best to apply it directly to the soil, as its composition and nutrient content do change if left. The urine can be applied via an irrigation or animal-slurry distribution system. The following are practical examples.

i. Joint experimentation with farmers

Experimentation was conducted in 2013 at the Aksum University compound, by farmers in collaboration with Aksum University

(AKU), The Best Practice Association (BPA), PROLINNOVA Ethiopia, the Institute for Sustainable Development (ISD) and Tahtai Maichew District Agriculture Office. Farmers were hesitant to believe the results, despite the fact that they had already been using urine for composting and for preparing biofertiliser (tea manure).

ii. A trial by Gebreyesus Tesfay

Farmer Gebreyesus Tesfay lives in Kewanit Village, near Axum. After he participated in the experimentation in AKU he took and tried it in his field in 2015.

Three maize fields were used in his experimentation, for (i) urine with water only, (ii) biofertiliser (plant tea manure), and (iii) chemical fertiliser.

The year 2015 was heavily stricken by drought. Summer rain shortages meant that the maize grown with chemical fertiliser failed because it dried before the corn matured. The maize field planted with urine diluted with water (with a ratio of 1:10) had well matured corn, as both the nutrients from the urine and the water to the field helped the corn to mature.

iii. Generic example

This example shows urine applied at homestead level on vegetables.

Figure 3: Spinach (Swiss chard) fertilised with urine, left (photo by Peter Morgan).

2.2.4 Managing Urine Safely

Human urine is almost perfectly sterile. When using it on vegetables, apply it to the soil around the plant. If you do apply it directly on to the plant, be sure to use clean water to rinse it off the leaves before consumption. For radishes, carrots and sweet potatoes, however, it is not a problem to apply it to the leaves or plants, since the edible part (the root) is below ground.

When using and managing urine, safety matters to keep in mind include:-

- Fertilise with urine solution a **maximum** of once a week. Fresh urine is the best to use, ie. applied within 24 hours of collection. After 24 hours urine begins to break down and the amount of ammonia increases. This can be too strong for plants, as well as amplifying noisome smells (while fresh urine has a much less strong odour).

- Do not apply any urine fertiliser less than two weeks before harvesting food crops.
- The primary problem with using urine as a fertiliser is its salt content. If you fertilise *solely* with urine, the soil may build up salts to a level which harm the plants, since too much salt kills the microbes in the soil.
- Don't apply urine to waterlogged or very clayey soil as these soil types hold onto salt for longer.
- One thing to watch out for with the long-term storage of urine is the crystallisation of phosphorous. Crystals form on the walls of containers but they can be broken up easily by stirring the urine occasionally. If applying through pipes and lines, simply run fresh water through after each urine application.

2.2.5 Conclusion

Urine is an easily available, valuable resource that should be harvested more widely than it currently is. By correctly harvesting and applying urine regularly, families and sustenance farmers can dramatically reduce their need for purchasing fertiliser.

Although urine contains generous amounts of nitrogen, applying it as a fertiliser is not enough since it lacks both macro and trace minerals. Urine as fertiliser is therefore best supplemented with chicken manure (to increase phosphorus) as well as kelp meal, granite meal and wood ashes (to increase potassium). Farmers like Gebreyesus have tried these combinations, with good results.

2.3 Composting Parthenium Weed

by Hailu Araya and Arefayne Asmelash

2.3.1 Introduction

Weeds play a considerable role in influencing crop yields and thus the socio-economic conditions of human beings, particularly in tropical agriculture. *Parthenium hysterophorus*, locally called *Qinche,* was apparently spread by army vehicles during the Ethiopia-Somalia war of 1976-77, and subsequently with delivered food aid. Its spread was initially observed in the eastern part of the country, along the main roads from the ports of Assab and Djibouti, but it has since spread throughout Ethiopia, and particularly densely in the Rift Valley, Somali and Afar Regions, the lowlands of northern Shewa, southern Wollo, and the Alamata-Mohoni areas of southern Tigray.

Figure 4: Parthenium and its biomass

Parthenium has negative impacts on human and animal health, as well as on the economy and the environment. It is unpalatable to livestock, threatens biodiversity, and quickly takes over both native and planted pasture. It produces large quantities of seeds and colonises areas with poor ground cover because its seeds are light

and easily dispersed by wind and by vehicles, machinery, and livestock, as well as via flooding, among other food grain and in fodder. Studies have shown that some people suffer severe allergic reactions to the weed.

Weeding in the tropical Africa generally costs farmers considerable time and labour, as well as reducing crop yields. Losses from weeds have been estimated at 10% in the less-developed and as high as 25% in the least-developed countries. According to a study by Tamado (2001[5]), Parthenium infestations in Eastern Ethiopia cause between 41% and 97% losses of sorghum yields.

In many places of the world, attempts to control Parthenium infestation have been practiced through eradication campaigns, but rates of successes have not been encouraging since the weed colonises new land faster than it can be controlled. However, on the positive side, the weed is now becoming recognised as useful for green-leaf manure, as a biopesticide (because it is repels insects), and as a raw material for making compost. Since 1996, the Institute for Sustainable Development (ISD), in collaboration with the local agricultural experts of the Bureau of Agriculture and Rural Development of Tigray, has been training smallholder farmers in preparing and using Parthenium in composting.

The main objective of this study has been to try and measure Parthenium weed's usefulness in making compost, and thereby its effect on crop production. Compost-making field trials were undertaken at the Selam Bikalsi Farmers' Training Center (FTC) near Alamata Town. Four combinations of biomass were used for preparing compost from the Parthenium weed:

1. 100% green Parthenium water to moisten the biomass was used, with no other biomass being added.

[5] Tamado Tana, (2001). Biology and Management of *Parthenium* Weed (*Parthenium hysterophorus* L.) in Eastern Ethiopia. PhD Thesis. Swedish University of Agricultural Sciences (AGRARIA 311), Uppsala.

2. 75% dry green Parthenium mixed in a 1:1 ratio with 25% other plant materials, animal manure, urine and water.
3. 100% dry Parthenium water to moisten the biomass was used but no other biomass was added; and
4. 50% dry and 50% green Parthenium with water were used to moisten the biomass, with no other biomass being added.

In order to facilitate the composting process, all the biomass used was cut into pieces. Compost samples were collected from each compost pit and analysed for electrical conductivity (EC), pH level, organic carbon (OC), nitrogen, phosphorous and potassium (NPK) and cation-exchange capacity (CEC). A germination test of the 100 seeds picked from the compost was planted in beds to find out if any of them were viable.

2.3.2 Effects of Parthenium

The *Parthenium hysterophorus* weed has spread onto about 97% of the cultivated fields of Alamata Woreda. The situation was first observed at the food-aid distribution centre in the north-east of Alamata town during the 1984-5 drought. The weed continues to invade farmed and grazing land and even the forests and higher slopes. Weed-control techniques being practiced for this study included burning and uprooting, making compost, household fuel and animal feed – as demonstrated in Table 1.

Table 1. Parthenium controls practiced by farmers

Practices	Use of parthenium by respondents	
	Number	%
Burning and uprooting	72	92
Compost	32	41
Household fuel	17	22
Animal feed	36	46

Although uprooting and burning is the most widely used control measure, compost making from Parthenium is a new activity which is being increasingly employed by farmers.

2.3.3 Compost

Parthenium weed is easily available for compost making for most of the farmers in the study area, but at present only 41% of the farmers use it for compost making. Table 2 gives the four types of compost preparation, dates and observations made when compost pits were opened.

The compost prepared from 75% of equal amounts of green and dry Parthenium mixed and 25% of other composting materials was well decomposed, having no seed or other biomass was visible. The pit with 100% green Parthenium did not decompose: instead it became compacted. Seeds were observed in the pit with 100% dry Parthenium biomass, but none of the seeds taken for germination test germinated within six months.

Table 2 – Results of the Parthenium compost making

Biomass used	Date made	Date opened	Observation
100% green Parthenium	May 2006	October 2006	Not decomposed and dark in color.
75% dry green Parthenium (1:1) and 25% other composting materials	May 2006	October 2006	Well decomposed, good smelling, color & structure
100% dry Parthenium	May 2006	October 2006	Well decomposed; seeds visible.
50% green Parthenium and 50% dry Parthenium at 1:1 ratio	May 2006	October 2006	Decomposed but not the stems of the *Parthenium*

2.3.4 Nutrient potentials

For pH levels between 7.7 and 7.9, all the Parthenium composts showed up as weakly alkaline. The high exchangeable cations also show the existence of more soluble salts in the compost. The pH of most yard waste compost is usually between 7.0 and 8.0. Higher pH goes with higher potassium (K) content, which is responsible for the high electrical conductivity (EC). See Table 3 below.

The carbon-to-nitrogen (C:N) ratio of Parthenium compost is between 18 and 21. A C:N ratio of less than 15 is an indication of limited nitrogen availability due to immobilisation within the soil. In mature compost a low C:N ratio, say below 6-7, is an indication that materials are humified, stable and suitable for field application and thus higher short-term effects on soil.

Table 3 - Nutrient status of Parthenium compost

Type of compost	pH H_2O	Electrical conductivity EC (ms/cm)	Organical Carbon OC (%)	TN (%)	Carbon:Nitrogen ratio C:N	Available P(*)	Available K(**)
75/25	7.71	1.76	4.92	0.24	21:1	342.20	6680.52
100D	7.92	4.71	8.72	0.43	21:1	392.90	10218.40
50/50	7.90	3.86	7.87	0.44	18:1	369.20	8481.27

Key: 75/25 - 75% dry green Parthenium mixed with 25% other composting materials; 100D - 100% dry Parthenium; 50/50 - 50% green Parthenium and 50% dry Parthenium; * - mg P_2O_5/kg; ** - mg K_2O/kg.

Organic carbon, which is an indicator of organic matter and nitrogen content of compost are shown as having good status in Table 3. Only the compost prepared from Parthenium was found to have a higher content of EC, OC, N, P, and K. The available potassium of the compost prepared from Parthenium is higher especially from dry Parthenium. The compost prepared by mixing with other composting materials was lower in nutrients but decomposes fast. A study conducted in India by chopping Parthenium, adding urea, dung slurry and fungi inoculation in a pit contained 1.05, 0.84, 1.11 and 2.88 % or N, P, K and organic carbon respectively[6]. Available phosphorous of all the compost ranges from 309 to 376 is at a high level for crop demand.

2.3.5 Effect on Yields

The highest grain and straw yield is from the compost prepared from 75% green and dry Parthenium mixed at a 1:1 ratio and 25% other composting materials – see Table 4 below. The Parthenium compost application to the main crops recorded the highest yield as compared to other organic waste compost and application of NPK alone.

Table 4. Maize yields at Alamata 2007 G.C

Biomass description in the pits	Yields per hectare (kg)	
	Grain	**Straw**
100% green Parthenium	2015	7052.5
75% dry green mixed Partheniumand 25% other composting materials	2687	9404.5
100% dry Parthenium	1107	3874.0
50% green Parthenium and 50% dry Parthenium	1685	5897.5
Average	**1873.5**	**6557.1**

[6] Sushilkumar, N.T. Yaduraju, K. Vishwakarma and S. Sondhia (2005). Utilization of Parthenium as compost. A Newsletter of National Research Centre for Weed Science, Jabalpur. No.5/4 (Oct-Dec 2005)

2.3.6 Conclusion and recommendations

- Experts and farmers are trying hard to control Parthenium, but there efforts alone are not enough. Training farmers in compost making from Parthenium weed can reduce its spread and improve soil fertility. Compost making is showing encouraging results with good nutrient levels, except for the high C:N ratio. Therefore, it requires further research to improve the C:N ratio below 10, which is good for faster mineralisation.
- Germination tests on the Parthenium seeds did not remain viable for six months. Maize yield produced by an equal amount of dry and green Parthenium mixed with other biomass and starters showed the highest result. It requires continuing test for the yield results on the most important lowland crops, including sorghum, teff and finger millet.

2.4 Multifunctionality of Biogas

by Hailu Araya

2.4.1 Introduction

Biogas is a source of clean, 'free' energy in the form of methane captured from within an airtight chamber. Biogas is collected from residual livestock waste (dung, manure and uneaten feed), food waste (fruit and vegetables, carcass residues, fish, dairy and brewery waste), industrial effluent and wastewater from municipal treatment plants. Bioslurry is the solid and semi-solid by-product of a biogas digester after methane has been generated.

Biogas technology has been introduced in Ethiopia by NGOs, as a source of lighting and cooking for rural populations, over the past 25 years. In spite of the many worthy projects undertaken, expected outcomes have not always been achieved. Reasons for this included the following:

(i) almost all biogas projects were not driven by users and direct beneficiaries themselves, but rather by external entities;
(ii) user understanding of operation and maintenance of biogasifiers has consistently been limited;
(iii) beneficiary families have had no or only limited water supplies and services are frequently interrupted;
(v) there were no schemes for provision of spare parts in place;
(vi) biogas was perceived to only be of limited use;
(vii) As most of the rural families need to bake their staple food called injera but injera-baking stoves fitting to the biogas energy are not available of in limited supply.

The National Biogas Project of Ethiopia (NBPE) is owned and hosted by the Ministry of Water, Irrigation and Energy in collaboration with the Dutch charity SNV. It is supported financially and logistically by the Ethiopian government at federal and regional levels. NBPE was started in 2009, intended for five years (until the

end of 2013) to build 14,000 biogas digersters in four regions (Amhara, Oromiya, SNNPR and Tigray). This was extended for a further five years (until the end of 2018) to build an additional 20,000 domestic biogas digesters in the four main regions. Some of the challenges listed above are addressed by the project, but outstanding difficulties arise from the lack of spare-part provision as well as a shortage of injera-baking stoves that have the approval of users.

2.4.2 Effects of the biogas project on family food security

Energy saving and the environment: Ada'a District

Ato Shume Deyas lives in Denkaka, a rural part of Ada'a Wereda in Oromia Region. He is one of the first biogas users under this project. He produces sufficient energy for cooking and light for his family. He has connected the family toilet to his biogas digester. According to him whenever the family visits the toilet frequently the gauge of the biogas showed at a higher level.

He calculated his average expense due to biomass use for energy consumption in one year over 9,000 Birr. Again he calculated his annual expense for chemical fertilizer purchase between 12,000 – 15,000 Birr for his 5 hectare of farmland. The expense for fertilizer is not only big but also requires to be purchased at once around May to June only while expense for energy is distributed throughout the year. Therefore, he designed a strategy to reduce the highest expense that affects the family by preparing compost from the bioslurry they are getting from the biogas. Now he produces enough both energy and compost to save all his expenditure. He became one of the producers of ecological tef and wheat in his area.

Addressing gender disparities

The work-loads at the rural families due to cooking, baking, fetching firewood, etc are shouldered on girls and mothers. It also creates burden in the children's education, which they can't read during their non-working hours mostly evenings due to darkness.

Now the biogas project are giving good opportunities for them that biogas energy is clean and quick for cooking. Moreover, men are voluntarily helping in the work which was allocated for female only. Therefore, children mainly ladies are getting time to read and do their homework by the biogas light.

Figure 5: Packaging and transporting biosulrry by Ato Atnafu

Benefits of bioslurry: Tillahun Tekka

Tillahun Tekka started production of sugar cane and other types of crops in 1990 on his land. Until 1997 he produced sugar cane without adding any inputs. From this he earned a limited income as there was no market demand for his sugarcane products and he could not attract many buyers. From 1997 until 2010 he began applying 150kg of chemical fertiliser per year. The sugar cane came

to look better, and his income increased. However, the price of the chemical fertiliser was also increasing.

In 2010 Ato Tillahun installed an 8m^2 biogas digester at his homestead. He started applying bioslurry in March 2012. His production quickly improved further, earning 17,000 birr from the first harvest, 18,000 birr from the second harvest (March 2013) and 12,000 birr from the third harvest (August 2013). After starting to use bioslurry, Ato Tillahun thus earned 47,000 birr from just 0.2 hectares of land. He has since used bioslurry on enset, gesho, coffee, banana, avocado, maize, and sugarcane crops, affirming that he has seen yield improvements on all of them.

Figure 6: Some examples of the farmers' orchards in Wondogenet

In addition to the yield increments gained from using bioslurry, Ato Tillahun has lowered his overhead costs by reducing to zero his purchase of chemical fertiliser. He has since built a new house on his compound, as well as buying 400 m^2 of land and constructing four rooms in Kella Town, costing 85,000 birr. He has also bought 0.4 ha of land for sugarcane production, costing 208,000 birr, 0.3 ha of other land for animal-feed production (costing 60,000 birr), an exotic cow (22,000 birr), six beehives (3,400 birr) and a cart with two horses.

Ato Tillahun has also enrolled his children in a private school. The family is now better clothed, eats better meals (including tef and maize in the diet, and the children being able to have a good breakfast before school), and they even have modern furniture a television and a gas cooker at home.

Making a success of bioslurry: Tesfanesh Bekele and Ato Buruso

In Mendera 1 Kebele, and across the Wendogenet District of the Southern Nations', Nationalities' and Peoples' Region, this couple are considered model farmers for their achievements with biogas (including its promotion), beekeeping, crops, livestock, poultry and coffee production, as well as tree planting and woodwork (making beehives and house furniture).

Wayzero Tesfanesh and Ato Buruso built their 8m^3 biogas plant in 2010, and they quickly became known for their innovative way of using bioslurry. They started producing and applying it to maize planted on infertile soil. Local people were eager to know what made the maize crop so healthy. The couple initially told the neighbouring farmers that they applied glucose, later explaining that it was bioslurry. Immediately they began to earn good income as local people became keen to buy bioslurry from them, and the business has grown, as well as productivity locally. Currently the couple sell bioslurry at 5 birr per jerry can (the hard plastic 20-25 litre bottle commonly used for transporting liquids).

Atnafu Lemma

Ato Atnafu started farming sugarcane by hole planting in 1991. His earnings were only 4,500-5,000 birr per 18 months, with a maximum sale of 0.4 birr per sugarcane stick. After seeing other farmers' practices of row and canal planting, meanwhile, he improved. From 2003 to 2008 he diversified his crops, including enset (or 'false banana'), papaya, avocado, coffee, maize and

vegetables such as pepper, tomatoes and green leaves. To these he applied manure. His earnings grew but still not sufficiently. From 2008 to 2010 he was trained by the agriculture office on the use of manure and the chemical fertilisers DAP and urea. In July 2011 he constructed a $6m^3$ biogas digester. Using the bioslurry on his sugarcane, he observed that the stems increased their thickness, length and tillers. The time to maturity also reduced by two months, to one year and four months.

Figure 7: Effect of bioslurry in coffee, vegetable and sugarcane around Wondogenet

Bioslurry also improved moisture retention and soil fertility, removing the need to compost during the coming year. By 2011 Ato Atnafu was earning a 42,250 birr per year; in 2013 this became 97,750 birr from the sugarcane and other crops, including adding a rented farm. Indeed, applying bioslurry improved the following *seven* sugarcane harvests, as well eliminating all chemical fertiliser costs after 2012.

Ato Atnafu has worked hard to improve his farming practices, and he has now expanded his farm by renting to other farmers. He bought two exotic milking cows in 2010, built a new house and motorcycle, and has enrolled his children in private school. He

frequently shares his best experiences with other farmers, as well as university students.

All the members of Ato Atnafu's family help with on-farm activities. His wife prepares injera for sale and the children help her selling it. He hires others to work with him. He says that the small land that he originally owned has widened his innovative capacity, forcing him to think better. 'The size of land does not change a family life, but the efficiency of the work invested.'

Although the examples above make clear that biogas benefits livelihoods, neither farmers themselves nor the government experts working with them have the sufficient levels know-how about the use of bioslurry to fully exploit its huge potential. Project partners should therefore build capacity of agricultural extension staff and farmers by organising experience-sharing events and training on the use of bioslurry for agricultural purposes.

3. AGROFORESTRY & HUMAN NUTRITION: MORINGA OLEIFERA

by Hailu Araya, Gizaw G/Mariam and Endris Mehammed

3.1 Introduction

Nick-names for *Moringa oleifera* include 'the miracle tree', 'the tree of life' and 'the super-food tree'. It is thought to be native to the Himalaya Mountains, but *Moringa oleifera* is not a new tree to Ethiopia, having been used for centuries by the knowledgeable people of Konso, as well as throughout the world.

Figure 8: Moringa tree and its seed pod

Moringa oleifera is a multiple-use tree in that every part of it is used, from the leaves to the small and large pods, both of which can be eaten. It is used to treat and prevent malnutrition in nursing mothers and infants. The health benefits of the tree are limitless. So far its known nutrients are as follows:

Organic nutrients include carbohydrates, proteins or amino acids, lipids, and vitamins. Inorganic nutrients include minerals. Vitamin A acts as a shield against eye disease, skin disease, heart ailments, diarrhea, and many other ailments. Vitamin C fights a host of

illnesses including colds and the flu while supporting the cardiovascular system. Calcium builds strong bones and teeth and helps prevent osteoporosis. The combination of vitamin D and calcium bring remarkable reductions to cancer risks. Potassium is essential for the functioning of the brain and nerves and significantly lowers the risk of a stroke. Finally, proteins are necessary for the basic building blocks - amino acids - of all of our body cells.

Interaction between nutritional compounds is necessary for health in all ways. Vitamins cannot function without minerals. Vitamins, minerals, and other nutrients are best absorbed and used by the body when they are derived from natural sources (plants and animals) and when they are present in naturally occurring complex compounds - not as separate compounds, as formulated in pills and tablets.

The human body requires 20 amino acids to grow, build, and maintain cells. Amino acids are the building blocks of protein. Amino acids relate to proteins as letters of the alphabet relate to words. The proteins in Moringa tea provide 18 of the 20 known amino acids, including all eight amino acids classified as 'essential'. These essential amino acids cannot be synthesised by the body and must come from a person's diet, usually from red meat or dairy products. Such foods are sometimes lacking in the diets of vegetarians, elderly people and children.

Moringa is considered a complete food because it contains all of the essential amino acids required for a healthy body. The dried Moringa leaf is a nutritional powerhouse. It contains all of the following amino acids.

- **ISOLEUCINE** builds proteins and enzymes and it provides ingredients used to create other essential biochemical components in the body, some of which promote energy and stimulate the brain to maintain a state of alertness.
- **LEUCINE** works with isoleucine to build proteins and enzymes which enhance the body's energy and alertness.

- **LYSINE** ensures that your body absorbs the right amount of calcium. It also aids in the production of antibodies, hormones, and enzymes.
- **METHIONINE** primarily supplies sulfur to your body, which is known to prevent hair, skin, and nail problems while lowering cholesterol levels since it increases the liver's production of lecithin. Methionine reduces liver fat and protects the kidneys, which reduces bladder irritation.
- **PHENYLALAINE** produces the chemical needed to transmit signals between nerve cells and the brain.
- **THREONINE** assists metabolism and helps prevent fat build-up in the liver while boosting the body's digestive and intestinal tracts.
- **TRYPTOPHAN** supports the immune system, alleviates insomnia, and reduces anxiety, depression, and the symptoms of migraine headaches. It also is beneficial in decreasing the risk of artery and heart spasms as it works with lysine to reduce cholesterol levels.
- **VALINE** promotes a sharp mind, coordinated muscles and a calm mood.

The ten 'non-essential' amino acids, which can be manufactured by your body with the help of proper nutrition, and are also found abundantly in *Moringa olifeira*, are:

- **ALANINE**: strengthens the immune system in muscle tissue, brain, and central nervous system by producing antibodies.
- **ARGININE** causes the release of the growth of hormones considered crucial for optimal muscle growth and tissue repair. It also improves immune responses to bacteria, viruses, and tumor cells while promoting the healing of the body's wounds.

- **ASPARTIC ACID** helps rid the body of ammonia created by cellular waste that when the ammonia enters the circulatory system, which can act as a highly toxic substance which can damage the central nervous system.
- **CYSTINE** functions as an antioxidant and is a powerful aid to the body in protecting against radiation and pollution. It can help slow the aging process, deactivate free radicals, and neutralize toxins.
- **GLUTAMIC ACID** it is food for the brain. It improves mental capacities, helps speed the healing of ulcers, reduces fatigue, and curbs sugar cravings.
- **GLYCINE** promotes the release of oxygen required in the cell-making process.
- **HISTIDINE** used in the treatment of rheumatoid arthritis, allergies, ulcers, and anemia.
- **SERINE** important in storing glucose in the liver and muscles. Its antibodies help strengthen the body's immune system.
- **PROLINE** extremely important for the proper functions of joints and tendons and also helps maintain and strengthen heart muscles.
- **TYROSINE** transmits nerve impulses to the brain. It helps overcome depression; improves memory; increases mental alertness; plus promotes the healthy functioning of the thyroid, adrenal, and pituitary glands.

Moringa oleifera contains more than 92 nutrients and 46 types of antioxidants**.** It is said to cure about three hundred diseases and to contain almost all the vitamins found in fruits and vegetables. With all so many health benefits, Moringa it is arguably the most nutritious herb on Earth. It can be consumed by small children and adults. Today, millions are using it in the form of porridge, pastas, bread and to reap its extraordinary benefits.

3.2 Nutritional Status

Moringa oleifera is a super-food to beat all other super-foods, even in its supplement form. The amount of anti-oxidants, anti-inflammatories, vitamins and minerals it contains is everything our body needs. It is proven that one serving of Moringa provides you with seven times the amount of vitamin C in oranges, four times the calcium in milk, four times the vitamin A in carrots, two times the protein in milk and three times the potassium found in bananas.

3.2.1 Managing blood pressure

Moringa oleifera contains four vital compounds your body requires for a healthy blood pressure: Niacin A1 and A5, and vitamins B3 and B10. It is the nutrients necessary to support your body's production of nitric oxide. These include magnesium, zinc, potassium, calcium and vitamin E. When your nitric oxide levels are healthy, blood flows properly through your blood vessels, thus reducing your blood pressure.

3.2.2 Protection against cancer and gastric ulcers

The antioxidant in Moringa oleifera supplement squashes all the free radicals that increase your risk of certain types of cancer disease and gastric ulcers.

3.2.3 Improved mood, mental clarity and anti-ageing

The combination of tryptophan, calcium and protein in *Moringa oleifera* generates a positive mind state. *Moringa oleifera* supplements contain iron, which is responsible for the amount of oxygen your brain receives, and zinc, which controls the amount of activity between the right and left hemispheres of your brain.

3.2.4 Moringa as antioxidant

The antioxidants in Moringa stop free radicals in their tracks, while the numerous proteins accelerate the regrowth of new cells. Additionally, vitamin A assists in the production of collagen and elastin, firming the skin and reducing wrinkles.

Moringa also increases the natural defences of the body, nourishes the eyes and the brain, promotes the normal functioning of the liver and the kidney, promotes proper digestion, takes care of the immune system of the body and promotes a healthy circulatory system. Moringa is an anti-inflammatory and supports the normal sugar levels of the body.

3.3 Preparing Moringa Oleifera

Moringa is generally prepared and consumed either by drying the leaves or by directly consuming the fresh green leaves.

Dry leaves

- Cut the young branches of a Moringa tree. Do not leave the cuttings in direct sunshine for long time without preparing it, as the leaves will wilt.
- Collect the deep green and young leaves of the Moringa tree by detaching them from the branches. Do not collect mature or old leaves.
- Put the leaves in an open and shady air until completely dry, then grind the leaves to powder.
- Fill and pack into dry and clean containers such as plastic bags or sealable containers.
- Then it can be used in all kinds of food stuff or drink such as tea, porridge, bread, injera, cooked rice, pasta, etc but not in alcohol.

Fresh green leaves

- Cut the young branches of a Moringa tree. Do not leave in a direct sunshine for long time as the leaves will wilt.
- Pick the young and deep green leaves of a Moringa tree. Do not collect the mature or old leaves as they don't taste good.
- The amount of leaves needed depends on the number of consumers or the availability of the leaves.
- Boil enough water for the amount of leaves you have prepared for cooking.
- Wash the Moringa leaves to remove dust and insects, and add them to the boiling water.
- Leave the boiling mixture, without stirring and uncovered, for 20-30 minutes.
- Taste the water. If it is bitter, discard it and add new water, waiting until this second round is boiling. If the water is not bitter, or if you want to use the bitter water, continue boiling until the leaves are thoroughly cooked.
- When the leaves look fully boiled, taste them. Once well cooked, add some onion, oil, green pepper and salt, and stir slowly.
- Taste for flavour and adjust the amount of salt accordingly
- Then serve the boiled leaves for eating.

3.4 Conclusion

Moringa oleifera can be grown in a wide range of agroecologies of the tropical regions. It has an attractive market everywhere, and as has been detailed, its health advantages are multiple.

4 LOCAL INNOVATION

4.1 Multiplying the Momona Tree

by Hailu Araya

4.1.1 Introduction

The Momona tree *(Faidherbia albida)* is one of the biggest of the acacia family in Africa. Roots can reach aquifers up to 80m below the surface. Young trees have an inverted, cone-shaped crown while old trees have a hemispherical large canopy. Young branches and twigs are cream coloured to whitish, appearing in straight axillary pairs and somewhat swollen at the base. Bark is grey, rough, deeply fissured and becomes scaly with age. Contrary to all other native acacias, *albida* sheds its leaves in the rainy season and keeps them throughout the dry season, which is made possible by the fact that the species behaves as a phreatophyte.

Figure 9: Momona tree ***(Faidherbia albida)*** with its wide canopy

Pods are typically bright orange to reddish-brown in colour, 10-15cm long and 2-3 cm wide containing 10-20 shining dark-brown seeds with a small characteristic tubercule. The tree remains leafless

during the rainy season and assumes new foliage and flowers with the commencement of the dry season.

The momona acacia is commonly distributed on flood plains and banks of large rivers on alluvial soil, where it may occur in pure stands or as a constituent of riparian woodland. Since its roots can reach water down to such impressive depths, the tree also survives in the dry lands of the Horn of Africa, as well as in the highlands of Ethiopia.

4.1.2 Uses of the Momona Tree

- Soil fertility: The momona enhances soil nutrients from the mineralisation of dropping leaves and branches: there is a marked increase in nitrogen, phosphorus and exchangeable calcium.
- Crop yields: It has been shown that crops under *Faidherbia* are, on average, 2.5 times taller than away from the trees.
- As the wood is soft and of medium quality it is used as timber, handicrafts, various tools, fuel and charcoal. It also serves as a windbreak.
- The momona makes good livestock feed during the dry season because it produces a large number of pods which are relished by shoats, camels, cattle and game animals.
- Its medicinal uses include febrifuge, haemorraghe, cough, pneumonia, kidney disorders, vomiting, diarrhoea, postpartum complications, psychological disorders, ophtalmia, rheumatisms and heart tonic.
- Three tree has good vegetation cover. The pods are indehiscent, and it is believed that passage through the animal is necessary to stimulate germination.

4.1.3 Propagation and Dissemination

Vegetation cover in Ethiopia is steadily reclining over time. The government is trying to increase forest cover by planting trees. However, survival rates are very low, and some communities, such

as Abreha We-Atsbeha in Tigray Region is not comfortable with the planting of various seedlings when it seems a waste of time, energy and resources. Instead they prefer to set up area enclosures.

One innovative way of increasing vegetation cover goes to the momona tree. It multiplies rapidly by creating injuries in its own roots. When a root is injured, a new seedling is regenerated around the mother tree, connected by its roots. In this way 2 or 3-metre high mother tree can breed up to thirty new trees in a year. From one large *Faidherbia albida* tree, then, a jungle forest area can appear within five years.

This innovative way of creating forest in a short time through momona multiplication can be spread into other communities (like Abreha We-Atsbeha) to boost vegetation cover, reduce land degradation, improve animal feed and enhance water retention. Springs have been reappearing in the Abreha We-Atsbeha community, for example

4.2 Shibaka: Ficus Thonningii (Blume)

by Gidey Hagos, Daniel Hagos and Hailu Araya

Vegetation cover in Ethiopia is declining due to increasing population pressures, poverty, land-use changes and other environmental and climatic challenges. As a result, human beings are limiting the benefits to them from ecological services.

Figure 10: Shibaka as street tree

The government, NGOs and communities are trying their best to improve natural resource bases, to varying effect. For instance, some farmers in Tahtay Maichew District of Tigray Region are trying to increase homestead vegetation cover of indigenous, drought-tolerant tree species such as Shibaka or Tsekente (*Ficus tonningii)*. The species propagates easily (from taking cuttings) and it provides medicine, wood, cash and year-round fodder for animals.

Figure 11: Shibaka as animal feed during dry season *(photo by Dr Muluberhan Balehegn and Mr Daniel Hagos)*

Shibaka has light green, narrow leaves while Tsekente has deeper green, wider leaves. The tree provides animal feed, firewood and shade during the hottest periods. Studies suggest that Shibaka is good source of nutrients (proteins, fats, carbohydrates, and minerals) as well as fiber, and it is within the recommended feed range for ruminant livestock growth and development. In Tahtai Maichew District of Tigray Region a group of innovator farmers and a research team has conducted research on the growth performance of the tree. According to the farmers, its rate of growth depends on the size of the branch, the season and the planting technique.

i. **Size of the branch**

The proper cutting trunk size of Shibaka tree is 10 cm or above. It is preferred to be a bigger sized branch than smaller. This is because whenever the dry season becomes longer, the newly grown tree from a bigger/thicker branch supports itself to survive from the stored food.

ii. Season

The best season to increase the survival rate of this tree is identified immediately before any short or long rainy season, ie. March–May and early June. Wet soil is not good for the survival of the plant because it can be rotten at its root part.

iii. Planting technique

(i) Take a tree cutting at the correct point; (ii) dig a pit half a metre in diameter; (iii) when digging the pit put the top soil on one side and the other soil on another side; (iv) collect some ash and mix it with the soil; (v) prepare a small flat stone to use when planting the cutting.

Table 5: Experimenting Shibaka cuttings in Tahtai Maichew Wereda

Farmer		Date	Local area	Number of cuttings	
				Planted	Survived
1	Abadi Berhe	June 2015	MS	15	10 (67%)
2	Fiseha Sibhatu	June 2015	MS	10	9 (90%)
3	Miesho Asgedom	June 2015	MS	5	3 (60%)
4	Birha Tadesse	June 2015	MS	6	6 (100%)
5	Gidey Hagos	June 2015	HA	20	19 (95%)
6	4 persons		MS	20	16 (80%)
Total / Average				**76**	**63 (83%)**

Key: MS – Mai Siye; HA – Hadush Adi.

When planting Shibaka, first put the flat stone where the center of the tree branch lies. This helps to protect direct contact with the soil. Then add the top soil mixed with ash, and then the under soil (also mixed with ash). The new root system will grow without being disturbed by soil or moisture whenever it rains. Having said this, the tree establishes its roots well before the main rainy season. Short rains are enough to trigger it. The above table shows the results of experimentation on survival rates of Shibaka by farmers in Tahtai Maichew District. The average survival rate is 83%, varying from 60 to 100%. This is much higher than regional average (53%) and the national average (59%) (Daniel et al., 2016 unpublished). The Shibaka plant is therefore good for increasing biomass and vegetation cover.

4.3 Fruit Harvester

by Kiros W/Gebriel

4.3.1 Introduction

Small-scale irrigation in Ethiopia is spreading like wild fire. The development of fruit and vegetable crops as a result is bringing big benefits to farmers who can sell the produce.

4.3.2 The Challenges of Irrigation

The main challenges to successful development of irrigation systems are the absence of efficient water use and water management, proper seeds and seedlings, post-harvest technology and efficient fruit-harvesting mechanisms. Fruit trees like mango, avocado, orange and papaya are becoming too tall to harvest. At the same time basic technologies like ladders are missing, and so farmers climb up, shake or through stones at their trees instead of harvesting them more safely and effectively.

Figure 12: Kiros demonstrating the fruit harvesting local machine

4.3.3 The fruit harvester tool

Innovator Kiros Weldegebriel, from Kilte Awlalo District of Tigray Region, was initiated to innovate a fruit harvester after observing farmers damaging their ripe fruits unnecessarily. He fixed two circular metal blades together to act like scissors, cutting the fruit from the tree. The cutter is attached with a rope connected to the handle at the bottom, and it has a bag to catch the harvested fruit as it falls. It can reach up to 3 metres in height.

Figure 13: Fruit harvester trying its efficiency

This cheap and simple innovation has targeted smallholder farmers. Kiros says that his fruit harvesting machine only cost him 40 birr ($2) to make, while its economic advantages for farmers is potentially very high.

The prototype fruit harvester was tried many times to evaluate how far its efficiency at harvesting could be optimised. It was tried on orange, avocado and mango crops and harvested an average of 5.5 fruits per minute, 100% free of human contact leading to zero contamination and longer storage life. All stakeholders who tried it approved its use.

4.4 Farmer-led Experimentation

4.4.1 Goat and sheep breeding

by Gidey Hagos, Yihdego Abay, Haileselassie G/Mariam, Bruh W/Mariam, Abreha G/Selassie, Hailu Legesse and Hailu Araya

The negative effects of climate change have become a critical influence on livestock production, as feed and water supply decrease. Farmers are trying to select adaptive animal breeds, diversifying the types of animals that they keep while reducing overall numbers.

The Ethiopian government is trying to introduce new animal breeds through the extension system in order to improve milk and meat supplies, as well as income of farmers. Many farmers are benefiting from this but not all new breed introductions have been successful due to management, feed, agro-ecological variations.

The breeds used for the research in this report were goats: One, Local female with local male (LL), Two, Begayit female with a Begayit male (BB) and Three, Local female with a Begayit male (LB). The joint research includes groups of farmers, Tahtai Maichew District Office of Agriculture, Axum Agriculture Research Center, Aksum University and experts from NGOs. The research was conducted in Hadush Adi and Mai Atsmi of Tahtai Maichew Wereda of Tigray.

Table 6: Goat breed selection research with farmers

Goat breed	Adaptation to local conditions	Milk production	Meat production	Rank
LL	***	*	*	**3**
BB	**	***	***	**1**
LB	***	*	**	2

The result of the joint research shows that local breed (LL), both female and male are good in adaptability to the local situation. The

cross breeds, local female and Begayit male (LB) grow faster and have adaptive capacity to the local situation. The BB, Begayit female and male, are quick to grow and give higher amounts of milk, but lower adaptive capacity than the other breeds (LL and LB). Therefore, families can get quicker and higher returns from the BB and LB than the local breeds.

4.5 Documentation and information dissemination by farmers

by Abadi Redehey, Demewez Hishe, Hailu Legesse and Abreha Gebreselassie

The Ethiopian Best Practice Association (BPA) promotes a variety of communication means to document information and share it among farmers, extension workers and other groups of people. The most important of these information-sharing methods are:

i. Photo and video documentation by farmers and extension agents.
ii. Sharing photos via CShare, using the application for all smart-phone users in proximity to each other.
iii. Facebook and website. This is not in the farmers' scope or level. Information shared to partners through Facebook, both own findings and other existing relevant links.
iv. A quarterly magazine called THE BEES in prepared and published in Tigrigna at quarterly level. It is shared throughout Tigray Region.
v. SMS (text) messaging in local languages through monthly. The original sender texts 100 first-level recipients. Each of them shares the SMS message with ten second-level recipients. Each second-level recipient then forwards the message to five more recipients. In this way the information reaches 5,000 people (10*100*5) every month electronically. In terms of oral information sharing, if each person reached by text informs at least to two other members in the family – a total of 10,000 people – then overall the information reaches 15,000 (5,000+10,000) each month. If, throughout the month, each person then shares new information with ten people, then the information's monthly reach extends to 150,000 (15,000*10).

5. SEED SECURITY FOR FOOD SECURITY UNDER SMALLHOLDER FARMING

by Hailu Araya and Arefayne Asmelash

5.1 Introduction

Ethiopia enjoys enormous geographical and climatic diversity, and as a consequence, great diversity of ecosystems and biodiversity.

Figure 14: Example of agrobidiversity in an Ethiopian family

The country is home to about 85 ethnic groups, each with its own with diverse agro-ecological knowledge and practices. For Ethiopian smallholder farmers, seed security represents food security, cultural and ecological diversity and economic and community stability. It is recognized that much of the knowledge and experience of seed selection, saving and exchange issues are held by farmers and farming communities. However, today seed systems and the success of crop production are under threat due to unreliable rainfall, drought, conflict, forced displacement, pests and floods reduce. As a result, farmers may be forced to use untrusted seed sources such as during the 1984/5 Great Drought, when they used wheat and maize seeds given as food aid.

5.2 Seed Sources

The informal seed-supply sector is a farmer-managed system that has its roots in the age-old tradition used by farmers to ensure the supply of their staple food crops. Unregulated and uncontrolled, it generally comprises on-farm seed selection and multiplication by local collections of farmers among themselves (Wobil, 1998).

Supply coverage by the formal seed sector is limited to 10-15% in Ethiopia. Meanwhile, farmers informally store their own seeds for their future cropping seasons and/or they exchange them with other farmers and communities. Small quantities of seeds are exchanged, and the sector depends on indigenous knowledge and local diffusion mechanisms. When farmers seek a certain seed strain, they may want a particular crop variety or a better quality seed than what they have at hand.

Table 7. Seed sources of 58 interviews from different community in Tigray Region during the 2002 harvest. (All figures are %ages)

Source	Teff	Wheat	Barley	Karka'eta	Maize	Sorghum	Millet	Pulses	Garden	Total
Personal	62.5%	36.8	42.5	15.4	42.2	66.7	36.4	61.4	17.1	**43.0**
Neighbor	7.5	15.8	22.5	7.7	26.7	22.2	45.5	4.8	4.9	**15.1**
Local Market	27.5	7. 9	35.0	76.9	22.2	11.1	18.2	33.3	56.1	**31.5**
Improved Seed	2.5	39.5	-	-	8.9	-	-	-	21.9	**10.4**
Total	**14.3**	**13.6**	**14.3**	**4.7**	**16.1**	**3.2**	**3.9**	**15.1**	**14.7**	**100%**

Source: Field survey

As Table 7 shows, informal sources are vital to the survival of the majority of people, particularly the under-privileged, as it provides seed at affordable prices with the availability of alternative payment arrangements. It also caters to farmer's varietal preferences, proximity of supply sources and stability of crop yields through the use of genetically broad verities.

According to farmers themselves, the challenges of the formal seed supply are not only related to accessibility, but also lack of confidence in seed sources, the need for high external input, and relative expensive – especially when farmers may be reluctant or unable to make up-front cash payments.

Figure 15: Seed preservation and storage by Borisso and Tesfanesh family in Wondogenet

5.3 Seed Selection, Saving and Exchange

According to Ato Gebremeskel Berhe of Wemberta District, Tigray Region seed selection is carried out in the field, at home or at the market. Elders, especially women, select seeds with big heads or grain sizes, long spikes or kernels, deep green leaves and stems, and originating from fertile, well-ploughed farmsteads which are known to have not been affected by disease or pests. In southern Tigray

Region a qualified elder, usually a man, is specifically hired to select sorghum seeds in the field during the harvest.

- When farmers select a given seed variety they put it in a special container or place. Sometimes people multiply quality seed on a designated portion of their farm plot.
- In Ethiopia, grain intended for seed is usually sealed in gourds or clay containers, often mixed with sand, wood ash (or 'weira', *aleo africana*) or plant materials (pepper, teff, 'bisana' i.e. *chroton macro stachys*) as a preservation against insects.
- In some cases farmers keep unthreshed heads of sorghum and cobs of maize hanging near fireplaces.
- In some places seeds are stored in underground pits. For example, in Gergera a woman migrated to Sudan during the 1984/85 drought hiding seed in a special place at home while her young daughter was with her. She never ate it while she was hungry because it is seed. She passed away but after the drought her seeds saved the family.
- Most traditional seed storage is in dry and cool places using containers made of animal dung, mud or ceramic in order to regulate temperature and to store seeds for a year or more without damage.

If a family does not have reserved seed at home, the responsibility is generally left with women to prepare part of the harvest at home. This may include exchanging seeds with neighbours or family members before the sewing season. They may be on a credit basis rather than upfront cash paid out, or leasing a portion of land to the donor farmer or sharing a portion of the harvest.

Buying seed from market is a last resort, and if it is to be done, information is key: a witness is usually sought to validate the seed source and its owner. Frequently asked questions include *Is this grain good for seed? Is it your own? Where are you from? Who around here knows you?* The seed seller often presents an eye witness or finds somebody known by both buyer and seller. If the above questions are not answered satisfactorily, purchase will almost certainly not take place. Prices are not set, rather agreed between buyer and seller. Buying seeds from market is men's responsibility.

5.4 Policy Environment

In 2000 GC the Government of Ethiopian announced a National Seed Industry Policy to help the country develop a more productive industry which benefits farmers. The legislation passed requires for compulsory registration of cleaners, sellers and testers of seeds, as well as naming varieties, grading quality, and bulking imports and exports. Within this, meanwhile, Proclamation No. 206/2000 acknowledges and encourages the traditional seed system. For example, article 3(2) states that *"the Provisions of this Proclamation shall not apply to a seed produced by a farmer, and sold directly to another farmer.*"

6. COPING WITH CLIMATE CHANGE

by Hailu Araya

6.1 Introduction

Over 85% of Ethiopia's population are rural dwellers, dependent on mixed, rain-fed farming on individual plots. Drought in Ethiopia has a long history, but has been aggravated and become more frequent since the 1960s due to the negative effects of climate change.

Figure 16: More animals, less feed - one example of the effects of climate change

Most Ethiopians are dependent on income opportunities that are highly sensitive to the weather. They have low adaptive capacity to deal with the consequences of stark climatic variability and changes. For example, unexpectedly heavy rainfall raises the risks of flooding, crop failure, drought and hunger, spelling disaster for crucial assets such as livestock.

6.2 Farmers' Perceptions of Climate Change

'Nowadays temperature has increased. We feel warmer in the early morning than before. Rainfall also fluctuates very much we cannot say surely what will happen.' - Aregay Se'are.

'Earlier there was a long rainy season, but now it has become short and unreliable. Every year nobody is sure about the onset and offset of the rainfall. We feel frustrated every year about the future of our crops.' Ato Teklu Berhe of Adi Guara.

'The onset of the main rains is later than before, and when the seasonal rainfall starts it is destined to flooding and erosion. My father used to plant late-maturing crops such as finger millet and sorghum, which give good harvest, but now we are shifting to short-season maturing crops. - Abadi Redehey.

'In the early days when we cut trees back they re-vegetated faster, but today they die. These days I never see again the trees I have cut down. This is a shame for me. I feel guilty and sinful.' – *[preferred not to be named]*.

Farmers respond to the effects of climate change both individually and communally, as they are felt over time. Coping strategies include cropping, diversifying crops, diversifying family income, working harder to access water and innovating.

6.3 Farmers' Coping Strategies to Climate Change

6.3.1 Coping with moisture stress

Growing areas of Ethiopia are becoming degraded as land is cut by gullies, the water table lowers and springs dry up. In order to counteract this, ground hydrology can be improved by conserving soil and water conservation, including by planting seedlings of trees, shrubs, herbs, grasses and legumes from cuttings or direct seeding. In addition to biological conservation, some communities build series of check dams, which help some springs to reappear. Some farmers dig shallow wells for small-scale irrigation.

Many communities reclaim gullies through integrated watershed management, which includes improved homestead gardening. Wayzero Medhin Gereziher of Mai Siye, Tahtai Maichew Wereda of Tigray Region, for example, lives beside a deep, wide gully. Her farm was one of the plots cut by gullies which developed during the

drought of 1984-5. Having understood that water was available at the gully floor after soil and water conservation (SWC) activities had been carried out, she built retention walls made of earth, later supported by check dams. She had to rebuild every year as floodwater washed the walls and dams away. She later built cemented retention wall in collaboration with the wereda agriculture office. Now she irrigates land near throughout the year and has a fruit orchard on the land between her house and the gully.

She also grows various tree types on the gully floor.

Figure 17: Wayzero Medihn's orchard

6.3.2 Coping with crop failure

Weather fluctuations have become more common and intense, leading to crop failure more and more frequently. Adaptation strategies practiced by farmers include the following.

- Many families in drier areas use manure, compost and biofertiliser to boost moisture-holding capacity of the soil. This is a more sustainable approach than applying fertiliser due to its cost.
- Another effect of climate change is the unreliability of the onset and off-set of rainfall. In response, farmers are shifting from

growing long-season, high-yield like finger millet and sorghum to short-season crops such as teff, wheat, crops. Farmers are preparing seedlings in nursery beds one month before the expected onset of rains. As outlined in Book One of best practices, this method is beneficial because:

(i) Crops mature in good time in the nursery beds.

(ii) Agricultural production increases.

(iii) It reduces the amount of seed needed versus seed broadcasting. For example, teff farmers currently use 25-30 kg/hectare for broadcasting. Transplanting teff in rows reduces this by ten times, to 2.5 kg/ha.

(iv) The method is efficient on inputs because it is applied in rows.

(v) Crops have stronger roots and stems, more tiller, longer spikes and more grains per plant. They are also more resistant to disease.

6.3.3 Seasonal selection of animals

Farmers divide domestic animals into two categories, large animals (oxen, cows, equines, camels) and small ruminants (goats and sheep, chicken, and bees). The larger animals are more vulnerable to stark weather changes than the smaller ones because they can't survive as well on limited feed and water. They are usually the first to due during drought. Coping strategies that farmers use for their domestic animals include:

- **Selective care -** Even though domestic animals are the backbone of smallholder farming systems, farmers don't view their animals equally. For example, more care is often given to oxen and donkey, being beasts of burden used for day-to-day activities. For an Ethiopian farmer, socially and economically, there is no life without oxen. Donkeys transport goods anytime, anywhere and in all seasons and weather situations. As the Tigrigna saying goes, *adgi zihaze yid'hn:* those who have a

donkey will be saved from hunger. Farmers keep an optimum number of donkeys for survival. Donkeys eat many types of plant as well as cattle litter, grain and human food. Donkeys are therefore the least affected by drought.

- **Diversifying animal composition** - By diversifying animal types, farmers reduce the risk of losing all in one go. Camels and goats are generally regarded as more drought-resistant than cattle and sheep. Rearing of smaller animals like bees and chickens, meanwhile, requires small amounts of feed, or even leaving them to search their own feed. Beekeeping is tolerant to drought because it makes and stores honey. Farmers say, "*If you want bees to feed you at normal times, don't put your hands in the beehive during a bad season such as drought.*"

- **Reducing herd sizes** – Farmers are finally coming to be convinced that owning fewer cattle is good to overcome weather challenges. Cut-and-carry feeding is an economically efficient approach which reduces herd size manageably. It also helps land to supply enough animal feed and distribute it among community members. However, it does require collective action in terms of protecting, managing, distributing resources (grass) and decision making, as well equal sharing of resources among members.

- **Fodder conservation and feed-source diversification** - Collecting and storing fodder has traditionally been performed by all farmers in Ethiopia. However, the amount of fodder most farmers store is usually only sufficient for one season. Since access to animal feed and landholding is reduced, looking for other sustainable options is a pressing issue facing thousands of communities.

  Many farmers come up with two options: collecting and buying feed from various sources, such as by-products of local beer production, and second, diversifying the type of animal feed by planting multipurpose trees such as prickly pear *(Opuntia ficus-indica* or 'beles') and Shibaka (*Ficus tonningii)*. These trees grow

happily in dry areas, and both stem and fruit of the prickly pear serve as animal feed.

6.3.4 Improving local apiaries

Although farmers can earn good income from beekeeping, bee colonies do sometimes flee their hives. Reasons for this are (i) low adaptation of a bee colony to a new place, especially if moving from lowland origins to highlands; (ii) lack of bee forage due to drying out; (iii) insufficient water supply and (iv) other insects which threaten bees or their hives.

Lots of bee colonies do not adapting to a niche area or micro-climate easily. Previously, farmers used to buy from distant locations, but the changing weather is restricting this. Instead, some farmers are ideas applying some of the following responses:

1. Splitting bee colonies within a niche area has increased their adaptation capacity. Most newly introduced colonies flee, while new colonies from nearby do not flee. Many farmers are seeking training skills on bee-colony splitting.

2. Attempts to broaden the quantity and seasonality of bee-forage availability by planting multipurpose trees and shrubs as a combined means of conservation, animal feed and bee forage on rehabilitated hills sides, homesteads and Farmers' Training Centers (FTCs). Some initiatives aim to include young people. in order to improve environment and their socially damaging lifestyle. Another approach is to collect, raise and plants seeds of flowering plants in a way which maximises the length of the flowering season, in order to supply bees with adequate forage.

6.3.5 Income and crop diversification

i. Since crop failure has come to be expected every year, farmers are adapting, for example to *Hanfets/Karka'eta* (in Tigray Region), which is a mixture of barley and durum wheat.

It is mixed during planting in order to minimise the risk of crop loss to rain shortage. It also includes double cropping.

ii. Most farmers are shifting from long-growing to short-growing season crops.

iii. The introduction of drought-resistant crops like improved hybrid teff, maize and wheat seeds released from government research stations increases yields by maturing early.

iv. Some farmers are making a total shift to vegetables intercropped with irrigated cereals and/or potato, which grow faster and need less rain.

Figure 18: Maize intercropped with cabbage (upper left), maize with tomato (upper right) and maize with faba bean (bottom)

v. Where good access to water is established and maintained, many farmers are shifting to growing fruit and vegetable orchards, which can generate income all year round as well as increasing personal nutrition as they grow fruits (in season) and vegetables (year round).

vi. The culture and practice of intercropping is now common in many parts of Ethiopia. It includes growing sorghum with tef, maize with tef, beans with field peas, wheat with barley and maize with sorghum. Intercropping mainly supplies consumption, protecting against crop diseases and pests.

Figure 19: Mixed cropping of tef with the niger or 'nuug' seed

Another means of adapting to climate change is engaging in off-farm activities such as construction work, investing in formal or informal education, or pursuing another, non-agricultural profession.

6.4 Conclusion

Agriculture, which is by far the main economic activity of Ethiopia, is dominated by smallholder farming and is highly vulnerable to the effects of climate change. Farmers' own remedial coping measures, as explored in this book, include enhancing moisture, varying their agricultural inputs, seasonal selection of animals, diversifying crops and varying cropping techniques. Encouraging and scaling up the practices that work for smallholder famers is the most direct way to address the issues facing their community and livelihood system.

Annex One:

Summary Report of Hawassa workshop on *Experience Sharing & Training on Climate Change: Adaptation and Mitigation*, 16-18 Dec 2014

Figure 20: Field visit observation in Sidama Zone, southern Ethiopia

1. Session One

1.1 Opening Remarks by Mr. Gelgelo Saddo from Ethiopian Evangelical MeKaneyesus

Mr. Gelgelo welcomed the participants and thanked Dr. Hailu Araya and the Best Practice Association for organising the platform of experience sharing. He also welcomed Mr. Anders Ölund from Uppsala, Sweden. He noted that such an experience sharing was conducted two years previously and that constructive feedback was obtained from that.

1.2 Introduction by Dr. Hailu Araya, Founder of Best Practice Association

According to Dr. Hailu, the experience sharing and training workshop helps participants to:

1) Integrate new and sustainable practices into their farms and projects;

2) Facilitate experience sharing communication among different organizations;

3) Prepares a third short report and story book of best practices.

Dr. Hailu also introduced the expected outcomes, outlined the programme outline and solicited expectation of participants.

Figure 21: Farmers learning from each other in Wondogenet

1.3 Paper presentations

Presentation 1: Sustainable Agriculture: Climate adaptation and Mitigation by Anders Ölund

Mr. Anders noted that global warming is increasing and that reducing greenhouse gas emissions remains a priority. He mentioned that by 2060, 40% of Arctic ice will have melted. When sea waters rise by 1 meter, 10% of Bangladesh and up to 10% of the Nile Delta will be flooded.

Mr. Anders presented scholarly evidence that CO_2 concentration in the atmosphere will double if current greenhouse-gas emission levels remain unchecked. He showed with diagrams, charts and illustrations the increasing nature of global warming over years.

According to Mr. Anders' presentation, half of the world's combustion to date has occurred since the late 1970s. The reasons for this are human activities like deforestation, cement production, burning of natural gas, burning of oil and burning solid fuels. He also indicated the amount of carbon each region of the world releases into the atmosphere. Africa contributes 7.8%.

Regarding mitigation in agriculture, Mr. Anders indicated the importance of crop- and grazing-land management, restoration of organic soil, management of water and bioenergy, livestock, manure and agroforestry management.

Mr. Anders also laid out the four pillars of Ethiopia's Climate-Resilient Green Economy (CRGE) strategy, which was issued in 2011:

Agriculture: Improving crop and livestock production practices for higher food security and farmer income, while reducing emissions.

Forestry: Protecting and re-establishing forests for their economic and ecosystem services, including as carbon stocks.

Power: Expanding electricity generation from renewable energy, with special focus on geothermal, wind, water and solar power for domestic and regional markets.

Transport, industry and buildings: Leapfrogging to modern and energy efficient technologies.

Mr. Anders emphasized the agricultural pillar, pointing out optimum soil practices to increase soil carbon and optimise nutrient management through green manuring, legume crops, double cropping of legumes, use of beneficial microorganisms and earthworks in compost making, residue management, terracing, water harvesting, agroforestry, soil and water conservation, small-scale irrigation, restoration of degraded land, crop rotation, nitrogen-fixing crops, and recycling compost, urine and manure.

Finally, Mr. Anders highlighted the importance of sustainable and organic agriculture for mitigating climate changes and boosting adaptation, resilience and productive systems.

This was followed by comments, questions and reflections.

Presentation 2: The Contribution of Innovative farmers to healthy soil by Dr Kassa Teka (Mekelle University), with Farmer Beyene Tadesse

Dr Kassa and Mr Beyene highlighted the importance of healthy soil for sustainable development, particularly through ecological agriculture. According to Kassa, use of ecological agriculture creates healthy systems in the soil, not only to obtain healthy products but also to enrich the soil for sustainable. One method of practicing ecological agriculture is applying compost and biosulrry.

Dr. Kassa also mentioned that Ethiopia is an agrarian country with high land degradation, ineffective agricultural yield and drought-prone land.

Then it was followed by the testimony of Mr. Beyene Tadesse as an ecological agriculturalist, using biogas technology since 2009 and receiving training in preparation of compost. He applied the compost and reaped a good harvest of 60 quintals of wheat grains during the first year from one hectare.

'I used the same land plot without compost the second year and I harvested only 40 quintals. I tried it again and in the third year it was 52 quintals. This was a kind of experiment for me that the residual effect of compost with the earlier compost still applied. If you use chemical fertiliser, however, the soil won't stay fertile year after year, it gives only a one-time benefit.'

Presentation 3: Soil Carbon and Soil Fertility by Anders Ölund

Mr. Anders explained the process of photosynthesis and how nitrogen, phosphorus and calcium are formed in the soil. He also illustrated how organic materials decompose into organic matter called humus. He also described the process of respiration and burning. In the presentation he said as all living things on Earth depend on microorganisms, organic matter in the soil and humus breaking down to release nutrients to crops.

Humus has a very high potential to adsorb cations and nutrients, but in order to do this most efficiently it should be loaded with nutrients from recycling (such as compost, plant residues or urine), or from DAP fertiliser.

Mr. Anders described the benefits of organic matter as a reservoir of slowly released nutrients, able to hold 90% of its weight in water, improving soil structure and water infiltration, reducing erosion and bulk density, increasing aggregate stability and resisting soil compaction. Organic matter thereby enhances fertility, reduces nutrient leaching, increases biological activity and reduces greenhouse gases.

Ethiopia's Climate Resilient Green Economy (2011) promotes the green-manuring of legume crops, double cropping of cereals, use of beneficial earthworms in compost making, and the usage of slow-releasing fertilizers, both organic and inorganic.

Question: 'Thank you Mr. Anders for your informative and educative presentation. You said that the amount of phosphorus in the soil in Sweden is greater by ten times than the amount available in Ethiopia. What is the secret behind that?

Answer: Farmers have been given sufficient inputs for many years in order to treat the soil in Sweden. The quantity of phosphorus is therefore in excess. This is not bad for the soil, but rather the phosphorus slips into the water (the Baltic Sea) where it affects aquatic life.

2. Session Two

2.1 Presentation 4: Alternative approaches: What can we do to increase soil fertility? by Hailu Araya

Mr. Hailu's presentation identified a number of options of how to protect crops against pests and how to maintain soil fertility. One option he described was using faeces and urine as a fertiliser. The majority of human and animal urine is pathogen free, and since it is easily accessible, its economic value can be recognized at an individual level.

Human urine is composed mainly of nitrogen, phosphorous and potassium, with an NPK level of 18 : 2 : 5. Urine is a fertilizer used for plants, particularly during their vegetative stage of growth. It is also a good compost booster as it adds much-needed nitrogen to bacterial colonies. The regular addition of urine to compost piles keeps them 'warm' and healthy.

Hailu illustrated with charts and graphics the chemical composition and steps required for preparation of urine as a fertilizer. He outlined application rates, time periods required and land sizes needed. Hailu also briefed participants about land rehabilitation experiences in Tigray and Wello.

He then described the pest control mechanism known as pull-and-push, used to control striga weed and stem-borer pest. 'Pull and push' uses types of plants such as desmodium between maize, sorghum or orobanche rows to generate unpleasant smells to moths and other insects.

Questions

1. Doesn't desmodium take nutrients from the main crops when planted between parallel rows?

   Answer: Desmodium doesn't harm the main crops because it is planted in a lower soil horizon while the main crop rows are positioned at a more elevated level.

2. When should the desmodium be planted, with the main crop, after or before?

   Answer: Desmodium can be planted simultaneously with the main crop, but it should preferably be planted first along with elephant grass.

2.2 Presentation 5: Ecological Pineapple Production in Aleta Chiko Wereda, Sidama Zone by Dejene Endeshaw

Mr. Dejene noted that he presented the situation of pineapple production by Farmer Muriso Mu'e who is cultivating organic pineapple in Aleta Chiko Wereda. According to the briefing, Mr. Muriso has a large family of two wives and twelve children. He owns 14.5 hectares of land. He cultivates ecological pineapple from his 6 hectares of land. He also grows chat on 4 ha of land, coffee on 3 ha and enset on 1.5 ha. Muriso also has 12 cows, 6 goats, 2 donkeys.

Dejene explained that Mr. Muriso propagates pineapple seedlings every month. He undertakes his farming through conservation, compost and manure. His ecological approach has helped with moisture retention, which is a blessing during the dry season.

His pineapple crop has many suckers from one plant, maturing quickly and giving higher yields than his neighbours. Mr. Muriso was a prize winner of one million Ethiopian birr in the 2000 and 2001 E.C. at federal and regional levels, receiving his award from the late Prime Minister Meles Zenawi. Mr. Muriso is therefore among the richest people in the SNNP Region: he has two houses in Hawassa – one for residence and the other as a hotel. His estimated savings are 750,000 birr.

2.3 The Effects of Bioslurry: Farmer Experiences

2.3.1 Experience share from Mrs. Tesfanesh Bekele

Mrs. Tesfanesh lives in Washa Kebele, Wondogenet Wereda, in Sidama Zone of the SNNP Regional State. She is married and has nine family members. She owns 4 hectares of land of which one hectare is covered by forest. She has 7 cattle and one donkey. She grows barely, tomato, tef, coffee, chat and other crops. Tesfanesh conducts integrated farming, including beekeeping (apiary).

'Bioslurry decomposes faster than conventional compost. I tried it first on the *chat* crop in 2003 E.C. (2011 G.C.) and it gave a good yield. I grow organic coffee and sell it 100 birr per kilo. I also sell a kilo of honey for 160-180 birr.' Tesfanesh added that she has oriented some 250 farmers about use of biogas technology.

2.3.2 Experience share from Mr. Atinafu Lemma

Farmer Atinafu Lemma is also from Washa Kebele of Wondogentet Wereda. He has 8 family members, 5 cattle and one donkey. He owns five hectares of land and does integrated farming of sugarcane, chat and tomatoes. His main success is with sugarcane production using bioslurry.

'I tried to grow sugarcane using chemical fertiliser on one side and bio-fertiliser on the other. The first died away soon while the one under bioslurry gave five rounds of harvest. I made the same experiment on tomato, and again, the ones planted with chemical fertiliser soon rotted.'

With the experiment on sugarcane Mr. Atinafu proved that sugarcane planted with chemical fertiliser took 17-18 months to ripe while that planted with compost took 14-15 months and gave harvests consecutively for three years.

Mr. Atinafu's experience share is testimony to how organic compost improves soil fertility and produces far better crops than using chemical fertiliser.

2.3.3 Experience share from Mr. Muqie Dangiso

Mr. Muqie is a farmer in Gido Kebele of Aletawendo Wereda in Sidama Zone. He has 10 heads of cattle and 2.8 hectares of land. He is a second-round beneficiary of biogas technology in his village, obtaining a 6,000-birr loan from Omo Microfinance Enterprise to build a biogas digester with an $8m^3$ holding capacity. He uses the bioslurry for *enset* (false banana), coffee, maize and other crops.

'The bioslurry-grown maize is of better quality and more desired at market. Also, the *enset* which is applied with bioslurry ripens faster than that grown with chemical fertiliser. My neighbours wondered what I used to get my products to be so good; I told them nothing but biogas technology.' As a result, some 30 farmers are following in his footsteps, using the by-products of biogas.'

3. Session Three

3.1 Presentations by the field-visit groups

Wondo Genet Group

This visit was made to Mr. Atnafu Lemma and Mrs. Tesfanesh Bekele in Washa Soyema Kebele. It explored biogas technology, compost preparation, sugarcane farming, inter-cropping, beekeeping and coffee cultivation. The hosts cultivate *chat*, coffee, tomatoes and other vegetables. They apply inter-cropping and they harvest vegetables up to four times a year. They have 250 modern and 60 traditional beehives, and their honey is branded as *Mechal Honey*.

Aleta Wondo Group

This visit was made to Mr. Muqe Dangiso of Gidibo Kebele and it covered biogas technology, compost preparation, coffee farming, inter-cropping and beekeeping.

Mr. Muqe is married with two sons and four daughters. He was a lieutenant under the previous government before becoming a carpenter in his home village. Wanting to change to farming, his father gave him ¼ of a hectare of land and he also inherited a small additional plot. On this he planted coffee and he started using biogas in 2011.

Suggestions made to Mr. Muqe visitors were: (i) 'Introduce integrated poultry farming as it supports other types of farming well'; (ii) 'Apply mulching on coffee and other crops'; (iii) 'Work with likeminded partners and neighbours to gain technical assistance and share experience'.

4. Closing Session

In this concluding workshop, the participants made promises to share best practices and experiences from their local areas, by written email submission to the Best Practices Association.

The last session was concluding the workshop training by participants made promises to share best practices/experiences from their local areas. All the participants are advised to write full stories of the ideas they presented and send them via email to Best Practices Association as soon as possible.

Finally, Mr. Anders Ölund made a closing remark by thanking all the participants for the enthusiastic efforts they demonstrated and the active participation they have done throughout the training workshop period.

List of Participants

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Best Practice Association

The Best Practices Association (BPA) is a non-profit making organization registered as an Ethiopian Residents Charity (NGO) based in Addis Ababa. BPA believes that the responsibility for providing food for all in Ethiopia is on the shoulders of its smallholder farmers. Hence, Ethiopian development is not possible without the success of smallholder farming. Despite decades of investment in research for improved technologies, these have not often met the needs of the farmers. Farmers do not sit and wait; instead they seek solutions for their own problems both individually and collectively. But these innovations are not given the value and visibility they deserve. BPA's aim is to identify, assess, share and promote the best practices used by farmers for other farmers as well those persons in processing, marketing and decision making so that everyone can feed their families in the wider rural and urban populations.
(www.bestpractice.org.et)

Pelum Ethiopia

PELUM Ethiopia, a member of the PELUM Association Africa, is one of the 12 member countries in Africa. PELUM, Participatory Ecological Land Use Management, is a network of civil society organizations passionate and working directly or indirectly with local communities in the areas of sustainable agriculture and natural resource management. They have taken a long-term development passion in the region. The need for PELUM Ethiopia is to combine efforts, approaches and experiences so as to build members' capacities in training and advocacy and in order to become more effective in influencing how development takes place through a harmonized advocacy.

Prolinnova

Prolinnova (PROmoting Local INNOVAtion in ecologically oriented agriculture and natural resource management) is a community of practice involving partners in over 20 countries in Africa, Asia and Latin America. Initiated by NGOs, this Global Partnership Programme under the umbrella of the Global Forum on Agricultural Research (GFAR) embraces both state and non-state organisations. It promotes recognition of local innovation by women and men farmers as an entry point to farmer-led participatory research and development. The ultimate aim is to integrate this approach into institutions of agricultural research, extension and education. The Prolinnova international network is hosted by ETC Foundation in the Netherlands (www.prolinnova.net).