Agro-ecological Practices Under Smallholder Management in the Horn of Africa A Special Focus in Ethiopia

You never fish a fish alone from agro-ecology

Compiled by
Hailu Araya Tedla (PhD)
(PELUM Ethiopia Consortium)

Financial support by
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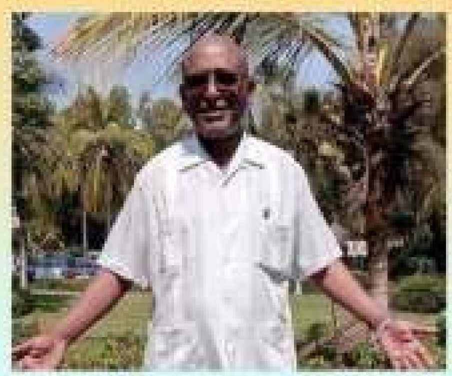
This book is dedicated to:

Sue Edwards

- She was one of the forefront runners in promoting and introducing Sustainable Agriculture in Ethiopian Smallholder farming system.



Gebremedhin Birega Digaga (Captain)

- Shambel Gebremedhin was one of the committed citizens in fighting for the right of consumers against the introduction of Genetically Modified Organisms (GMO) in Ethiopia.

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Foreward

Agroecology is not new; it's the most proven and sustainable method of food production system, which our ancestors have used for centuries. However, today's challenges of feeding an ever-growing world population have put it to their greatest test.

PELUM (Participatory Ecological Land Use Management) - Ethiopia was started to promote agroecology in Ethiopia and the Horn of Africa. It connects with other PELUM networks in East and Southern Africa for joint advocacy, resource sharing, and collaboration.

Bread for the World supports smallholder farmers worldwide in claiming food sovereignty and choosing agroecology as their preferred means of food production system. Using agroecological food production methods serves is best suited as it provides a holistic approach to farming while at the same time preserving the natural environment, thereby allowing local communities to thrive.

This book provides a comprehensive study of the concept of agroecology, its background, potential, and challenges in the Horn of Africa. It further provides examples by smallholder farmers of their practice and successes in using agroecological food production methods. It invites others to join the movement and to scale up agroecology in their interventions.

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Abbreviation

ADLI - Agriculture Development-Led Industrialization
AGRA – Alliance for Green Revolution in Africa
BMZ - German Development Cooperation
BFTW – Bread for the World

CBO- Community Based Organization (Idir)
CRGE - Climate Resilient Green Economy
CSE - Conservation Strategy of Ethiopia

CSO - Civil Society Organizations
DAP - Diammonium phosphate

EIAR – Ethiopian Institute of Agriculture Research
EECMY-DASCC - Ethiopian Evangelical Church Mekane Yesus Development and Social Services Commission
FAO – Food and Agriculture Organization
FAW – Fall Army Worm
FRG – Farmer Research Group

FSN – Food Security and Nutrition
GDP – Gross Domestic Product
GIZ – German International Cooperation
GMO – Genetically Modified Organization
GTP - Growth and Transformation Plan
HLPE-FSN - High Level Panel of Experts on Food Security and Nutrition
HYV - High Yielding Variety
ICBA - International Center for Biosaline Agriculture
ISD – Institute for Sustainable Development
IFAD – International Fund and Agriculture Development
IGAD – Inter-Governmental Development
IPM – Integrated Pest Management
ISFM - Integrated Soil Fertility Management
ISWC – Integrated Soil and Water Conservation
ISWCP - Integrated soil and water conservation Practice

LEISA - Low External Input Sustainable Agriculture
MoA - Ministry of Agriculture
NBSAP - National Biodiversity Strategy and Action Plan
ND – No Date
NRM – Natural Resource Management
NTFP – Non-Timber Forest Products
PAN E – Pesticide Action Nexus Ethiopia
REST – Relief Society of Tigray

SCI - System of Crop Intensification
SDG - Sustainable Development Goals
SG-2000 - Sasakawa Global 2000
SIHA - Strategic Initiative for Women in the Horn of Africa
SNNPR – South Nations, Nationalities and People's Region
SSA - Sub-Sahara Africa

SRI - System of Rice Intensification
SWC – Soil and Water Conservation
TAPE - FAO's Tool for Agroecology Performance Evaluation

TWN – Third World Network
UNCTAD – United Nations Conference on Trade and Development

UNEP – United Nations Environment and Population
UNESCO - United Nations Educational, Scientific and Cultural Organization

USAID – United States Agency for International Development

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CHAPTER ONE

INTRODUCTION

1.1 Background

1.1.1. Brief history of agriculture

Population of developing nations in general and Ethiopia in particular are dependent on agriculture, which has the oldest history. Agriculture has been estimated to be as old as between 7,000 in Ethiopia (TewloldeBerhan, 2006) and 12,000 year in the Nile Valleys (Jules Janick, 2014). This shows that it has supported survival of millions of people for several centuries. This traditional agriculture has evolved into several distinct systems with pastoral and agropastorla systems in arid and semi-arid, crop-livestock mixed farming practice in the highlands and nature-based wet- humid agroecosystems being among the major ones. These systems used to provide sufficient food and fiber for the population of the region and were sustainable production systems based on agoecological based principles which are always in harmony with nature.

Nowadays the global food system is at a crossroads (HLPE, 2019) due to population growth, land degradation, and climate change variability. These days, agricultural production with the existing land degradation and climate change nexus is unable to produce enough to feed the ever-increasing global population. Agricultural practices are changing from time to time and different actors are joining to surrender the farming system by the name of modernizing agriculture. Scientists and policy makers are focusing on boosting agricultural outputs to produce more food as today's challenges and they express the need for a new global agricultural model. The wider perspective of environmental connectivity is forgotten. The Green Revolution has failed to ensure safe and abundant food production; and monocultures are heavily dependent on pesticides (Altieri and Nicholls, 2012). All agricultural-revolution based programs are expensive and unsustainable. Escalating prices and production and consumption risks have been cited as one of the factors limiting the use of inorganic fertilizer in Ethiopia (Kassie *et al.*, 2008; Dercon and Christiaensen, 2007). The intention of industrial agriculture is not competing or complementing, it is colonizing agriculture instead. They want to avoid smallholder farming system.

1.1.2. Types of agriculture

There are different types of agriculture production systems/practices but the major ones are classified into four major groups. They are: 1. Traditional agriculture; 2. Sustainable agriculture; 3. Conventional Agriculture; and 4. Modern Agriculture.

The four main agricultural practices are:

- **Traditional agriculture**: It is also called subsistence agriculture, smallholder agriculture, etc. follows and employs different agroecological based production approaches. Traditional agriculture practice uses little or no external inputs and relies on natural nutrient recycling system together with indigenous agricultural production techniques which are developed by farmers.

  Moreover, traditional agricultural practice is heavily reliant on agrobiodiversity; resilient and adaptable to climate change; enhances ecosystem services; it work in harmony with society (Nafeez, 2014) and nature; favouring beneficial insects (Tadesse *et al.*, 2017; Wagg *et al.*, 2014; Sinclair, 1999; Tscharntke *et al.*, 2011); it is one of the most resource use-efficient agricultural management option through optimizing the use of locally available resources; minimizing losses of soil, nutrients, water and energy (Altieri and Nichols, 2005). It holds all the necessary practices fitting to the local situations, which is called agroecological system.

- **Sustainable agriculture** is an agricultural system involving a combination of sustainable production practices (Kassie *et al.*, 2009), which reduces or avoid uses of production practices that are potentially harmful to the environment (D'Souza *et al.*, 1993). According to FAO (2008) sustainable agriculture consists of the following major attributes: it conserves resources (e.g. land, water, etc), and it is environmentally non-degrading, technically appropriate, and economically and socially acceptable. It enable poor farmers to avoid the financial risk of buying chemical fertilizer and problem of late delivery of chemical fertilizer (Kassie *et al.*, 2009); compost and conservation tillage higher and/or comparable yields, compared to chemical fertilizer (Edwards *et al.*, 2007; Hemmat and Taki, 2001; SG-2000, 2004; Mesfine *et al.*, 2005; UNCTAD and UNEP, 2008); there are evidences with clear superiority of crop yields with the use of compost over chemical fertilizers (Kassie *et al.*, 2009).

- **Conventional agriculture:** This type of agriculture mainly focuses on the use of modern inputs. It supported by agricultural extension with blanket recommendation of fertilizer for all agroecologies and crops with less attention for farm diversification. By focusing on grain yield increment it is ignoring the farmer managed cropping system.

  As example of conventional agriculture, the Agricultural Green Revolution involves the uses of external inputs including high yielding varieties and modified agricultural management. The use of external inputs (high yielding varieties, fertilizers, pesticides and herbicides) had led to significant increment in crop yields (Kropff *et al.*, 2001) and food production (Pretty, 2008; Gold, 2016) in East Asian countries. Unfortunately, unintended side effects accompanied these positive developments with the green revolution. Natural resources were jeopardized (Kropff *et al.*, 2001), and different forms of environmental degradation (air and water pollution, soil depletion, diminishing biodiversity) became apparent (Horrigan *et al.*, 2002). Moreover, the expected production increase does not sustain more than short time honeymoon (Hailu, 2010). In this situation, environmental concerns appeared that conventional agriculture was described as unsustainable (Ikerd, 1993; Dahlberg, 1991; Francis and Youngberg, 1990) and, therefore, alternatives to conventional agriculture were often seen as sustainable practices.

- **Modern agriculture**: It is a farming system dependent on applying technology and information to control most components of the farming system such as access to resources, technology, management, investment, markets and supportive government policies (Shyam R. Dutonde, 2018). It is also called industrial agriculture as it is related to laboratory structures or installations in their production system. From the very beginning, it starts from lobbying and advocating for a full policy support. This type of agricultural system does not complement to the existing smallholder farming system; instead it controls and degrades smallholder agriculture to be under their full control. For example, the introduction of GMOs into Ethiopian agricultural system is through pushing for the introduction of the debatable outputs of genetic manipulation, GMOs, into the country. Some of the already targeted few crops, especially the endemic Ethiopian crop, like ensete (USAID-GAIN, 2020) would be endangered. Application of unreliable technologies with the aim of modernizing the agricultural production system may lead to unpredictable impacts on the sector, in general, and on iconic crops like ensete, in particular. Such case will put food and nutrition security; resilience; food sovereignty and social, economic and environmental sustainability in question and finally kill indigenous practices, resilience capacity and resources, biodiversity, and will promote monopoly of the global agriculture by few companies.

When we refer the types of agriculture it is about the changing agriculture from traditional to the industrial agriculture. With a view of addressing agricultural problems and reduce poverty, many governments introduced a number of policies, strategies, and plans. Ethiopia's agricultural growth over the past decades has been central to the economic growth of the country. Official numbers indicate that the value of agricultural production in Ethiopia has more than doubled since 2000 (FAO, 2018). Moreover, it has been officially declared that Ethiopia has registered a double digit economic growth with agriculture playing a leading role. However, although practically smallholder management is dominant but their contribution to the growth is not recognized.

1.1.3. The politics of agriculture

By the way whose is agriculture? The controversy of agriculture starts by the name of modernizing it by treating agriculture as a business firm. In reality, agriculture is not a commodity only its products can be sold. It is embedded within a wide-ranged human knowledge, wisdom, and identity. Then, it belongs to all of us based on its purpose that is, for some of us agriculture is important: to feed our stomachs; a business firm for those aiming making profit; a field of science for research purpose useful instrument for politics, etc. It belongs to both the smallholder farmers and consumers where society and consumers can demand sustainable agriculture (Norman Siebrecht, 2020); they took it as major part of their life to feed, live, employ, etc. as farmers have to implement it ultimately (Norman Siebrecht, 2020). Generally, it is everything for all of us. However, business actors in corporate companies forgot they are consumers too. Then, they go for profit and sell their agricultural ethics for money because it has profit. The politics of agriculture starts through lobbying for strict policies on input utilization especially privatizing seed. They insist policy makers to restrict with a vision of controlling the system than complementing the agricultural system.

However, the good news is global institutions are opening their eyes on the importance of the holistic approach of agroecology. The HLPE report says "agroecological approaches and other innovations for sustainable agriculture and food systems that enhance food security and nutrition (FSN)" during the 46th CFS Plenary Session in October 2019 (HLPE. 2019). The HLPE explores the potential contributions of agroecological and other innovative approaches, practices, and technologies.

In previous reports, the HLPE highlighted the huge diversity of food systems across and within countries but these food systems are situated in different environmental, socio-cultural and economic contexts and face very diverse challenges involving a variety of actors at different scales in a coordinated and integrated way in order to achieve the transformation of food systems towards FSN and sustainable development. Agroecological and other innovative approaches are also attracting attention because of their capacity to contribute to the design of scale-specific interdependent processes. Understanding and assessing the issues that fuel the debate are keys to allow policy-makers to design and implement concrete avenues towards sustainable food systems at different scales (HLPE. 2019). Moreover, in July 2019, the German parliament approved the motion 19/8941 "Achieving Sustainable Development Goals – recognizing and supporting agroecology opportunities", calling for further commitments of German Development Cooperation (BMZ) in this field paying increasingly attention to agroecology (Kundermann and Arbenz, 2020).

1.1.4. Agroecology

Agroecological farming is one of the oldest types of farming systems, which combines elements of traditional farmers' knowledge with elements of modern ecological, social and agronomic science, creating a dialogue of wisdoms from which principles for designing and managing biodiverse and resilient are derived (TWN, 2015). It is a pillar of the food sovereignty framework that promotes the provision of land, water, seed and other productive resources to smallholder farmers and landless people, along with economic opportunities (TWN, 2015). Since 1993, it was recognized focusing that "diversified farmers" are needed, that they "must be more knowledgeable, more creative, and more skilled", in order to manage the sustainability challenge (Ikerd, 1993). Smallholder farming practices are more sustainable than large farms, which is based on diverse management strategies (e.g., high agrobiodiversity or use of landraces) and these farmers care more about resource-efficiency and are generally more motivated and committed (Roland Ebe, 2020).

1.1.4.1 Defining agro-ecology

Agroecology is referred as a scientific discipline, a practice and as a social movement. However, it is not uniformly defined and understood. Big differences can be observed between geographical areas (Examples: between Latin America and Africa; and among stakeholders) with respect to what agroecology mean (Kundermann and Arbenz, 2020). There are no definitive set of practices that could be labeled as agroecological approach, nor are there clear, consensual boundaries between what is agroecological and what is not (Kundermann and Arbenz, 2020). Although there is no clear and agreed definition of agroecology, there are13 principles and 10 elements that serve as a guide to understanding its meaning (GIZ, 2020). These principles and elements indicate that agroecological practice is derived from the God's way of agriculture. However, for some of researchers or professionals it is newly born approach. It is not new; may be it is mentioned in publications by academicians in the last century (Paola Migliorini et al., 2018). This indicates that they understand and then joined the agroecological approach. Farmers created agriculture, they continuously experiment with peers, observing and learning from what works best in their local context (BFTW, 2016).

To mention some simple definitions:

- "A science, a practice, and a movement based on traditional and scientific knowledge. It is a science that bridges ecological and socio-economic aspects" (TWN, 2015).
- ''The science of applying ecological concepts and principles to the design and management of sustainable food systems" (Gliessman 2015).
- Farmer Abadi Redehey around Axum, Ethiopia, "A farming system that care and support all of us together with nature i.e., all living things created by God."

Many professionals say "agro-ecology is a science".It is true, but it is a science based on an old- aged practice. In this matter the true agro-ecological practice is implemented and carried-over to generations through practice by smallholder farmers as oppossed to research reports. Here, the truth is researchers/ scientists joined the practice to study in the work of farmers. There is weak connectedness and togetherness for knowledge sharing between farmers and researchers/ academicians. It is clear that nowadays farmers are no more recipients; they are demanding to be heard but there is no true linkage. Therefore, "agroecology is the practice and/or science of agricultural system in its natural way by recognizing and caring the existence of all natural families." This refers to all visible and invisible living and non-living things within the interconnections. This shows that agro-ecological practice is based on applying ecological concepts and principles to optimize interactions among plants, animals, humans, and the environment while taking into account the social aspects that needed to be addressed for a sustainable and fair food system. By building synergies, agroecology can support food production and food security and nutrition while restoring the ecosystem services and biodiversity that are essential for sustainable agriculture.

1.1.4.2. Principles and elements of agro-ecology

FAO (2018) has identified thirteen principles and ten elements of agroecology. They are grouped into three as enhancement of resource efficiency, empowerment (strengthening) of resilience, and securing social equity/responsibility i.e. 1-2, 3-7 and 8-13 agroecological principles, respectively. Gliessman (2016) has shown their linkage with proposed framework for classifying "levels" of food system change (Table 1 below).

Table 1: Consolidated set of 5 food system change levels, 13 agroecological principles, their scale of application and correspondence to FAO elements of agroecology.

Food system change	FAO's 13 principles	FAO's ten elements	Scale application*
Level 5: build a new global food system, based on equity, participation, democracy, and justice	Participation (13)/ Fairness (10)/ social value and diets (9)	Human and social values	FA, FO
	Land and natural resource governance (12)	Responsible governance	FA, FO
Level 4: Strengthen connections between growers and consumers and develop alternative food connections	Co-creation of knowledge (8)	Co-creation & sharing of knowledge	FA, FO
	Social value and diets (9)	Culture and food traditions	FA, FO
	Connectivity (11)/ Economic diversification (7)	Circular and solidarity economy/ balance	FA
Level 3: Redesign the agroecosystem	Biodiversity (5)/ Economic diversification (7)	Diversity/ balance Diversity	FI, FA
	Synergies (6)	Synergies/ balance	FI, FA
	Animal health (4)	Resilience	FA, FO
Level 2: Substitute alternative practices for Industrial input	Recycling (1)	Recycling	FI, FA
	Soil health (3)	Regulation, balance, diversity, synergies, resilience	FI. FA
Level 1: Increase the efficiency of industrial inputs	Input reduction (2)	Efficiency, partly balance	FI, FA

***Scale application:** FI = field; FA = farm, agroecosystem; FO = food system
Source: derived from Nicholls et al., 2016; CIDSE, 2018; FAO, 2018c
Adopted from HLPE 92019) and Wezel et al., (2020); Gliessman (2016)

According to Gliessman (2016), there are five steps to transform food systems toward the ultimate goal of sustainability away from the negative impacts on the environment and society caused by industrial agriculture. The first three levels describe the steps farmers can implement on their farms for converting from industrial into agroecosystems (Gliessman, 2015). Two additional levels go beyond the farm to the broader food system and the societies in which they are embedded (Gliessman, 2016). All five levels taken together can serve as a roadmap to outline a process in stepwise manner in transforming the entire global food system. Each level is briefly described as follows:

- **Level 1:** Increase the efficiency of industrial and conventional agricultural practices in order to reduce the use and consumption of costly, scarce, or environmentally damaging inputs. The primary goal of change at this level is to use industrial inputs more efficiently so that fewer inputs will be needed and the negative impacts of their use will also be reduced (Gliessman, 2016).
- **Level 2:** Substitute alternative practices for industrial/conventional inputs and practices. This is to replace external input-intensive and environmentally degrading products and practices with those that are more renewable, based on natural products, and more environmentally sound. Good example is employing alternative practices that include the use of nitrogen-fixing covercrops and rotations to replace synthetic nitrogen fertilizers, the use of natural controls of pests and diseases, and the use of organic composts for improving soil fertility and soil organic matter management. However, at this level, the basic agroecosystem is not usually altered from its more simplified form; hence many of the same problems that occur in industrial systems also occur in those with input substitution (Gliessman, 2016).
- **Level 3:** Redesign the agroecosystem so that it functions on the basis of a new set of ecological processes. The fundamental changes in overall system design to eliminate the root causes of many of the problems that continue to persist at Levels 1 and 2. Due attention is paid to prevention of problems

before they occur, rather than trying to control them after they happen. A good example is the reintroduction of diversity in farm structure and management through actions like ecologically-based rotations, multiple cropping, agroforestry, and the integration of animals with crops (Gliessman, 2016).

- **Level 4:** Re-establish a more direct connection between food producers and consumers. Food system transformation occurs within a cultural and economic context, and this transformation must promote the transition to more sustainable practices. At a local level, this means those who eat must value food that is locally grown and processed, and support farmers who are attempting to move through Levels 1–3 (Gliessman, 2016).
- **Level 5:** On the foundations created by the sustainable farm-scale agroecosystems achieved at Level 3, and the new relationships of sustainability of Level 4, build a new global food system, based on equity, participation, democracy, and justice, that is not only sustainable but helps restore and protect earth's life support systems upon which we all depend. By thinking beyond Levels 1–4, Level 5 involves change with global perspective and reaches beyond the food system to the nature of human culture, civilization, progress, and development (Gliessman, 2016).

1.1.4.3. Importance of agro-ecology

Agroecology has lots of advantages when it is in place. Agroecology is not merely an agricultural production approach:

- It reduces the need for external inputs (fertilizer, pesticides, etc.), recycles plant remains, and harnesses biological processes to grow food with emphasis on harmonious human relationship with nature (BFTW, 2016). The input reduction also reduces environmental and health hazards due to soil and water contamination through external input utilization.
- It maintains agrobiodiversity significantly in the agricultural system and in agro-environmental system. Above-ground biomass diversity is managed to maintain and restore natural soil fertility while below-ground functional biodiversity increase microbial activity. **C**rop diversity reduces the risk of crop failure and other climate-related shocks. High levels of below-ground biodiversity are crucial to soil and crop health. Diversity increases opportunities for coexistence and for beneficial interactions between species that can enhance agro-ecosystem sustainability. Greater diversity improves resource-use efficiency in agro-ecosystems. The existence of all life forms in the soil is the sign of fertile and healthy soil i.e., healthy soil grows healthy plants for human and animal use. Agroecology important for sustainable development, food security and food sovereignty, as well as for conservation of biodiversity and ecosystem services (HLPE. 2019).
- Agroecological practices optimize interactions among plants, animals, humans, and the environment building resilience and adaptation to climate change. Diversified systems tend to be efficient in capturing sunlight, in using rainfall and in mobilizing and tightly recycling nutrients, exhibiting close efficient energy flow. Natural ecosystems have the ability to self-regulate and attain a natural balance between pests, disease and natural enemies, that is potential for sustaining pest control functions and restoring natural balances. For instance, the diverse plants observed in many Ethiopian farm plots have a number of defense mechanisms to various organisms, outbreaks of diseases, insects or weeds are uncommon.
- Building food systems based on the culture, identity, tradition, innovation, and knowledge of local communities and livelihoods, favoring social dynamics focusing on women's and youth's role in agricultural development. Farmers and communities are at the heart of food production and consumption. Respecting and recognizing the social values and decision-making within food systems is vital to achieving food security and nutrition (Gliessman, 2016); they are guardians of natural and

genetic resources ensure a fair and inclusive food system. Farmers and food producers need to have access to natural and genetic resources, including land and water through respecting the customary use and practicing a landscape approach to land governance at the community level (FAO, 2017).

1.2. THE STUDY

1.2.1. Objectives of the study

This study focuses on assessment and identification of challenges and opportunities of agro-ecological practices in the Horn of Africa (Figure 1) with a special focus on Ethiopia. The main aim is to come up with practices, which are acceptable by smallholder farmers, pastoralist, and agro-pastoralist societies in order to recommend similar development works for partners of the Bread for the World[1]. The specific objectives are:

i. To identify main opportunities and challenges of the agro-ecological practices in the Horn of Africa.

ii. To identify locally accepted[2] agro-ecological practices for wider scalability in Ethiopia and beyond in the Horn of Africa.

iii. To identify effective and sustainable locally tested agro-ecological practices (case studies) that can improve environmental health[3], food security, nutrition, and food sovereignty in pastoralist/agro-pastoralist and mixed farming areas.

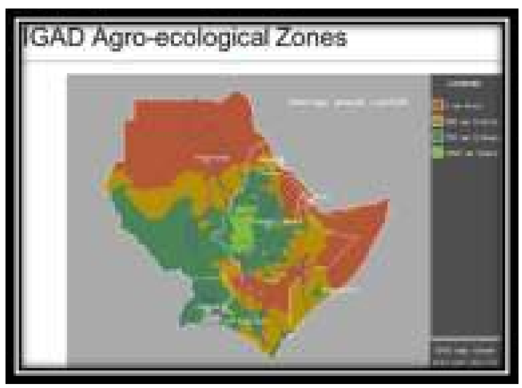

Figure 1: The Horn of Africa (IGAD) Region
Source: IGAD secretariat document

1.2.2. Scope of the study

The study was conducted in three countries of the Horn of Africa (Ethiopia, Somalia, and Sudan) with a special emphasis on Ethiopia. The main focuses of study were soil moisture availability, land use management, and differences in the agricultural practices in the context of the Horn Africa Region. Agroecological classes covered by this study are described as follows:

i. Highland areas:

[1] Brot für die Welt (Bread for the World) is the globally active development and relief agency of the Protestant Churches in Germany. It takes steps to make sure that there is enough food for everyone. Because fighting hunger becomes increasingly important in times of climate change and ever scarcer resources.

[2] Locally accepted agro-ecological practices mean economically benefiting, environmentally safe and socially accepted practices by farmers, pastoralist or agro-pastoralist.

[3] This refers to improving soil fertility and health; reduces plant, soil, water pollution; reduces any risk to any life forms.

The highlands are characterized by crop-livestock mix with complex cropping system. The highland areas in Ethiopia are located in to two parts of the country. These are:

(1) Northern highland covering from central Ethiopia to Eritrea across Shewa, Wello, Gojjam, Gonder, Tigray, Gamo highlands, etc. Generally, it is found between west of the Great Rift Valley and East of the western Lowlands facing Sudan. Main economic activities are on: Crop-livestock mix with complex cropping system Gojjam, Gondar, Wollo, North Shewa and Tigray. It is extended into the highlands of Eritrea. Escarpments of the Ethiopian Rift Valley interlinked with agro-pastoralists of the Afar Region (Eastern and Southern Tigray, Eastern Wollo and North Shewa areas – sorghum and chat mix area). Central Tigray and Sokota are also sorghum area. Wollo and North Shewa area: livestock with barley, wheat; teff; faba bean mix; chat mix; sorghum, etc.

(2) The Southeastern highland covers Arsi, Bale, highlands west of Lakes Abaya and Chamo in the southern Rift Valley, Harerghie extending into the highlands of Somaliland. Main economic activities are on: Arsi-Bale: livestock with barley/wheat mix and some potato while Harerge: Chat-maize and coffee mix.

ii. Humid and sub-humid areas:

Humid and sub-humid areas are characterized by permanent crop with forest, coffee, banana, root-crops, spices, etc. They are sub-divided into two.

- **South West:** This part which comprises Gambella, Benishangul, Kaffa, Jima and Illubabor areas with known to grow coffee, maize, bamboo, spices, mango, pineapple and edible herbs as herbal medicine. These areas are also known for honey and fish production.
- **Central South:** It is known for its diverse root crops and mixed cropping practice. It is mainly found in Gedeo, Sidama, Wendo Genet, Gamo Highland, Konso, Wolayta and Gurage. They are known for diversity traditional agro-forestry dominated by root-crops dominated by enset. They are also known for the indigenous soil and conservation practice such as the UNSECO registered SWC of Konso. However, the commenrcial cotton and vegetable farms around Southern Rift Valley Lakes are highly challenged by pesticide application. At the same time it is a place where organic cotton production by smallholder farmers using food spray as plant protection is also practiced. The introduction of highland fruits is also observed in many part of Hadiya, Kembata-Tembaro, Wolayta and Chencha highland.

iii. Arid and Semiarid areas:

They are characterized by low or no moisture availability with pastoralist and agro-pastoralist economic activities. They are highly dependent on livestock production of cattle, sheep and goat, camel, etc. Whenever there is unreliable rainfall they dominated by transhumance cattle movement from lowland to highland and vice-versa into the neighboring highlands. Even though it is well accepted since long by the neighboring highlands sometimes it is a source of conflict. This covers most part of the Eastern escarpments of the Ethiopian highlands facing the Rift valley (Tigray, Wollo and North Shewa); Metehara – Gewane; Borana (Guji, Moyale, Somali, and Negele Borana), weredas in Afar, Somali, Debub and Oromiya Regions. It also covers part of Djibouti, Somaliland and Sudan.

iv. Urban areas:

They are characterized by limited but intensive types of economic activities in confined spaces. Urban agriculture supports many people but it is also a source of many socio-economic challenges. For example, they are competing for space, pollution, etc. The focus areas are Addis Ababa, Adama, Mekele, Hawasa, Dessie, Bahir Dar, etc.

v. Agroecology in institutions:

This refers to agroecological practices and initiatives by organizations such as religious, development, research and academic institutions. The aim of this category is to see how far these institutions are recognizing, treating or practicing agroecological farming systems. This will see what inputs are using to enhance soil fertility or crop protection, how are they teaching/training their students in agroecology related topics/courses. Focus areas are churches and mosques (Christian and Muslim faith organizations), research organizations, academic institutions, development organizations, government institutions, etc.

1.2.3. Methodology used

The methodology used in this study included:

- The Horn of Africa is classified into three (highlands, humid/sub-humid and arid and semi-arid). One additional class (urban areas) was added because it is found everywhere in all the three agro-ecologies. Institutions are added as a system to see their (negative or positive) contribution to the agro-ecological practices.
- Researchers who are experienced to these agro-ecologies were identified and hired to conduct data collections.
- After orienting the researchers, they were sent to the different agro-ecologies for field assessment.
- Different means of capturing information were used including meetings, questionnaire, focus group discussion, observation, referring different documents, photos, etc.

Different meetings in order to reviewing the field reports were conducted.

CHAPTER TWO

THE HORN OF AFRICA

2.1. Bio-physical condition

The Horn of Africa Region is not totally desert or dry as it is often considered (Giessen, 2011); instead it is 55% arid, 15% semi-arid, 16% sub-humid, 2% humid and 12% highland zones (Osman et al., 2015). The hydrology and ecology of the region are directly correlated with its altitude. It has rich biodiversity from afroalpine vegetation in the Ethiopian highlands to the desert and semidesert lowlands (Dawelbeit, 2008; Venema, 2007). Ethiopia and South Sudan are rich in their agro-biodiversity due to their higher altitude and moisture availabilty (FEWS, 2013; Desalegn, 2008). Often, Ethiopia is called the water-tower of Africa (Desalegn, 2008), almost all of its great rivers drain/flow from the Ethiopian highlands to the neighboring countries: Somalia, South Sudan, and Sudan are dependent on the rivers from the Ethiopian highlands (Osman et al., 2015; Dawelbeit, 2008; Venema, 2007). The diverse ecology of South Sudan is due to its unimodal rainfall regimes (SSCSE, 2006). The two most important ecological zones are the woodland savannah and the flood region (USAID, 2007).

Socio-demographically, it is endowed with high human and animal population. In 2013, the human population of Djibouti, Eritrea, Ethiopia; Somalia , South Sudan and Sudan were estimated at 0.9, 6, 99, 10, 12 and 40 million respectively. In almost all countries of the region, the avaerage life expectancy is less than 62 years and characterized byhigh human poverty index and least human development index (Osman et al., 2015). Socio-culturally and religiously Ethiopia and South Sudan are very diverse than Djibouti, Somalia and Sudan but all have strong social bondage. This part of Africa is known as politically unstable (Osman et al., 2015) experienced with widespread war, conflicts, displacement and home for many refugees (SIHA, 2011; Muhabie, 2015). Poverty line in Ethiopia was about 30 percent in 2010/11 (Alemayehu and Addis, 2014); in South Central Somalia 89% are poor compared to 75% in Puntland, and 72% in Somaliland (UNDP, 2012). However, the social capital of the Horn of African people has overall importance; for example, it has helped Somalia to stabilize their people without official government (Osman et al., 2015).

The World Bank report (2013) indicates gender disparities remain persistent in Somalia and Sudan; in Sudan women comprise only 23% of the formal economy, but 70% of the informal economy, with a majority of them engaged in agricultural production. Serious poverty in women headed families is aggravated due to the involvement of men and young people in war, conflict and migration. For example, there was shortage of agricultural workers in areas of Somalia with rainfall for cultivation (Osman et al., 2015); in South Sudan crop production is mostly conducted by hand cultivated plots farmed by women-headed households (World Bank, 2013). Therefore, the responsibility of women became double on caring the family and land management in the weak or no available food security options suitable for women (Osman et al., 2015).

2.2. Economic Conditions of the Horn of Africa

The economic setting of the region is mainly related to the agro-ecology, socio-cultural, environmental and political situation of the region. Crop-livestock mixed in the highlands and cattle rearing in the arid and semi-arid lowlands are dominant practices.

All most 85 percent Ethiopian population are rural and agricultural (Xinshen Diao, 2010). Its agricultural production accounts for more than 40% of national GDP, 90% of exports, and provides basic needs and income to more than 90% of the poor (Xinshen Diao, 2010). About four-fifths of the Somali population engaged in agriculture and pastoral farming (Ruggieri, 2004), it contributes to more than 65% of GDP; 50% of total employment; about 80% of the exports as the main source of the country's foreign currency earnings (Ruggieri, 2004). Over half of its population is dependent on nomadic pastoralism (Drydale, 2000); traditionally they are oriented towards trade and export (Abdullahi, 1990). About 83 % of South Sudan (Tizikara and Lugor, ND) and 70 % of Sudan population live in the rural (IFAD, 2010). Pastoral farming systems on natural rangelands and are mainly semi-nomadic including transhumance type of grazing. Under agro-pastoral farming system with slight available water sources the growing of some crops and livestock production are the main sources of income and food (FAO, 2006). In 2008, agriculture provided 90% of the national food requirements, constituted 80% of non-oil exports, and accounted for 32% of GDP (IFAD, 2010) of Sudan.

Generally, pastoralism has a contribution of 57% of the agricultural GDP in the IGAD Region (Osman et al., 2015). Most of the animals are the source of asset, milk and meat even the source of identity for the pastoralists of the Horn Africa (Osman et al., 2015). Therefore, agriculture is employing and feeding more people than any other human activity (Barrios et al., 2015).

Inhabitants of forest based farming systems which is found in high rainfall receiving areas of South-western Ethiopia and South Sudan depend on the extraction of forest products, shifting cultivation, hunting, gathering and some pastoral livestock herding (Dixon et al, 2001). Riverside and lakeside farming system is crop cultivation supplemented by fishing and livestock. The wide rainfall regimes, flooding and fertile soil of South Sudan are sources of wide range of agriculture and fish species (USAID, 2007) and various forest products (Diao et al., 2012). Market oriented agriculture mainly in urban, peri-urban and commercial farming such as vegetable growing, dairy farming and livestock fattening is becoming important activity in the region (Dixon et al., 2001; FAO, 2011).

The Horn of Africa is challenged by an ever increasing threat due to unexpected weather situation destined to drought, famine and flooding (Ginkel, 2013) ultimately resulting in loss of agricultural production (Fowler and Hodgkin, 2004). Moreover, there is high post-harvest crop losses (Osman et al., 2015) mainly due to poor infrastructure that is lack of storage facilities, transportation, communication, inadequate financial services and/or access to market (Osman et al., 2015).

However, many agroecological activities such as mixed-farming, pastoralism and agro-pastoralism have shown that it can address the challgnes of women, climate change, pre- and post harvest management etc. in one way or another due to their adapting to the existing socio-cultural, economical and political situations and they are run and managed by family labour as means of food, employment, income, etc. Such as existing agroforestry practices can simultaneously contribute to income generation, food security and the conservation of biodiversity and ecosystem services (Sinclair, 1999; Tscharntke *et al*., 2011). These types of agriculture are more resource use-efficient agricultural management options through optimizing the use of locally available resources similar to the ecological based cotton farming at Arba Minch has increased yield (Tadesse et al., 2017).

These diversified economic activities of the region have survived for many centuries throughout the political changes because it has an ever-practiced activity with its socio-political importance. Therefore, it is supported by government policy because of its importance addressing the challenge of ending hunger and malnutrition in all its forms, central strategy for addressing climate change and building resilience (DeSchiutter, 2014). Moreover, agroecological farming is embedded in sound socio-political institutions and it is the most promising pathway for achieving sustainable food production; it is also a social movement for justice that recognizes and respects the right of communities to decide what they grow and how they grow because it is related to the to land, nature, to each other and to sustainable livelihood (DeSchiutter, 2014).

CHAPTER THREE

CHALLENGES OF AGROECOLOGICAL PRACTICES

Although our global food system is at a crossroad, agroecology offers the possibility of win-win solutions through building synergies, increasing food production, and food and nutrition security while restoring the ecosystem services and agrobiodiversity essential for sustainable agricultural production systems (FAO, 2015). However, at present it faces different types of challenges. This study has identified lots of challenges, which negatively impacted agroecological practices in the Horn of Africa particularly Ethiopia. The challenges are grouped into two broad categories. These are:

3.1. Human-induced challenges

3.1.1. Land degradation

Land degradation includes all processes that diminish the capacity of land resources to perform essential functions and services in ecosystems (Hurni et al., 2010). Its processes include physical erosion, overgrazing (Said M-Shidad, 2017), chemical degradation (comprising acidification, salinization, fertility depletion, and decrease in cation retention capacity), physical degradation (comprising crusting, compaction, hard-setting, etc.) and biological degradation (reduction in total and biomass carbon, and decline in land biodiversity) (WMO 2005). Throughout the highland, arid, and semi-arid environments, land degradation problems are extensive including bare landscape mainly in Ethiopian highlands. They are highly degraded and the environment became less resilient, more and more fragile and drought prone; resulted into low and declining agricultural productivity and production which in turn rural poverty affecting food security and the wealth of nations, and has an impact on the livelihood of almost every person on Earth (Bezuayehu et al., 2002); affect the type of plant grown on the area, reduced availability of potable water, depletion of aquifers and biodiversity loss (Temesgen et al., 2014).

3.1.1.1. Soil erosion

Agriculture is the main economic activity of Sub-Sahara Africa (SSA) and/or Ethiopia (Hailu, 2010) and many derive their livelihoods from it (Erkossa et al., 2015) but challenged by land degradation such as footpaths develop into gullies, soils become thin and stony, topsoil is gone etc (Stocking and Murnaghan, 2001). Among the SSA countries, Ethiopia has a highest level of soil erosion (Mekonnen et al., 2015; Gessesse et al., 2016). Continued soil erosion seriously threatens peoples' livelihoods, where arable land is a very scarce resource. Moreover, many researchers do not recognize the importance of local knowledge (Zerihun et al., 2017) and practices in managing their soil erosion for millennia.

3.1.1.2. Soil health and fertility decline

Many studies point out the widespread processes of nutrient mining and soil fertility decline (Scoones and Toulmin, 1998) due to the continuous cultivation and soil degradation (Bationo and Mukwunye, 1991) with severe consequence of decline in agricultural productivity and production (Stocking and Murnaghan, 2001; Elias, 2002; World Bank, 2007). Over 50 % of the highlands in general and cropped areas of Ethiopia are in an advanced stage of land degradation (Elias, 2002). Soil organic matter (SOM) content and nutrients are generally lower, where land degradation is more severe (Elias, 2002; Tegene, 1998). It leads to poor soil structure consequently to water erosion (Sivakumar and Stefanski, 2006). Farmlands are extremely deficient in nitrogen, available phosphorous and organic matter (Tesfay, 2006; Mitiku et al., 2003).

Studies in and around Hargeisa between 1982 and 2006 indicated a decline in the soil nutrient conditions as it was revealed by decline of soil organic carbon content by as much as 50% while calcium-magnesium ratio and carbon-nitrogen ratio had increased by over 100% (Vargas et al., 2009). The study by Said M-Shidad (2017) also reported there is severer soil loss in Somalia due to livestock herding, resource mismanagement, overgrazing, erosion, traffic movements, etc and living soil has mostly been lost.

Throughout the smallholder farming systems of Africa negative nutrient balances of nitrogen and phosphorus are reported (Ncube et al., 2009). Farmers remove the crop residues to use them as household fuel material, for local hut construction etc along which nutrients mainly such NPK removed or exported without adding enough nutrients to the soil (Dechert et al., 2005; Elias et al., 1998). This situation entails that there is a need for restoring nutrients for a better production. Jones (1972) suggested only 3-years fallow to restore the soil organic carbon, NPK and Mg that were depleted in a 3-year growth period while Harris (1998) generally indicated an extended resting period. But this is likely impossible in many places in Africa especially in Ethiopia because farmers are forced into non-fallowing intensive cultivation due to shortage of land (Bationo and Mukwunye, 1991; Saleem, 1998; Snapp et al., 1998). In many studies nutrient balance analyses show homestead plots, where farmers mainly apply organic fertilizer are reported positive nutrient balance (Haileslassie et al., 2005).

3.1.1.3. Soil acidity

Soil acidity affects large parts of the Ethiopian highlands associated with high rainfall due to leaching of soluble soil nutrients down to the sub-soil. Soil acidity affects up to 6.5 million hectares of Ethiopia's agricultural land mainly in Oromiya, SNNPR and Amhara Regions. The soils are characterized with low pH within the plough layer. Soil acidity is resulting in significant crop yield losses and even land abandonment. According to the study by MoA and EIAR (2014), the effect of soil acidity on wheat production alone is estimated to cost the country over 9 billion Ethiopian birr per year.

3.1.1.4. Expansion of salt affected soils

Soil salinity and sodicity problems are commonly found in the arid and semi-arid regions of the world due to insufficient annual rainfall to leach down accumulated salts from the plants root zone (Lemma, 2019). Salt affected soils have been reported to occur in most parts of the Rift Valley Zone of Ethiopia (Lemma, 2019) and newly irrigated areas with insufficient water supply. Observing white crust and dark brown color of the soil in the farmland are the major sodicity/salinity identification indicators used by the households (ICBA, 2018). Considerable area of land is becoming unproductive every year because of salinity and sodicity in Lowlands of Ethiopia (Okubay, 2019). Most of the landholdings are affected by salinity with different ratios of production loss including abandonment of farmlands (ICBA, 2018). Most of the recommendations to reduce the effect of salinity/sodicity rely on agroecological practices such as irrigation water management; application of gypsum, installing surface and subsurface drainage systems; selection of suitable plant varieties adaptable to highly salt-affected lands, integrated crop-livestock technology packages etc (ICBA, 2018).

3.1.2. Agrobiodiversity decline

Ethiopia is one of biodiversity rich countries in the world (EBI, 2014). It hosts two of the biodiversity hotspots of the world, namely: The Eastern Afromontane and the Horn of Africa hotspots (EBI, 2014). It has ten ecosystems, and 18 major and 49 sub-/minor agro-ecological zones (EBI, 2014) endowed with great diversity of plant, animal, and microbial genetic resources. Ethiopia has estimated 6000 species of higher plants of which 10% are endemic (EBI, 2014); 284 species of wild mammals and 861 species of birds. It is centre of origin for cultivated crops such as coffee, teff, enset, and centre of diversity for many crop species such as durum wheat, barley and sorghum (EBI, 2014). Main direct threats to Ethiopia's biodiversity are poor habitat conversion, unsustainable utilization of biodiversity resources, invasive plant species, replacement of local varieties and breeds with exotic ones, climate change and pollution (EBI, 2014).

The highest diversity (number of taxa per Flora region) is found in the Southern, Eastern, and parts of Western and Central Ethiopia and western Eritrea (Friis et al., 2005). The endemics make up 29% of the taxa that occur in Somalia, 17% in Ethiopia, 7% in Eritrea and 3% in Djibouti (Friis et al., 2005). The highest number of Horn endemics is found in north-eastern Somalia. The highest number of single-region endemics (Horn endemics restricted to one Flora region only) is also found in north-eastern Somalia (Friis et al., 2005). The higher diversity in Ethiopia than in Somalia is correlated with the higher altitudinal range in the former country and agrees also well with the higher climatological diversity in Ethiopia, while the higher endemism in Somalia than in Ethiopia agrees with the observation that the Flora regions in Somalia have higher proportion of their perimeter as coastline and shorter distance to the tip of the Horn, possibly a “peninsular effect” (Friis et al., 2005).

There is agrobiodiversity variation such as:

- **Ethiopian highlands:** The so called modernity of agriculture supported by the agricultural extension and the negative effect of climate change has affected different types of crop varieties to restrict their cropping pattern. For example, farmers are shifting from long growing seasoned crops like finger millet, sorghum, maize, etc. to short growing seasoned crops requiring light and short rain such as tef. The shift is not only by crop variety but also the diversity within the crop variety. Moreover, the extension is also insisting farming families to go for high yielding variety (HYV) or improved variety of crops, which require additional external inputs application. However, farmers are not comfortable on these crops because these crops reduce their yield over years (Sue et al., 2010).
- **Humid and sub-humid lands:** Biodiversity loss in the humid and sub-humid refers to the reduction of forest and non-timber forest product diversity. These areas are rich in forest resources but are at risk due to logging especially by investors. Investments in humid and sub-humid areas of Ethiopia are exploitative.Investors are practicing logging through forest clearance and then market their lumber due to lack of sufficient understanding of ecological farming system. There is frequent forest fire occurrence in most part of the South west and western lowland forest. Forest fires occur either naturally or deliberately set by local people to improve grass species for animal feed while others clear their environment from dangerous animals such as snake and invasive weeds. However, by any means forest fire is one reason for the loss of different fauna and flora such as medicinal plants, wild edible species and bamboo. Consequently, there is no clear follow up on the impact of these investments.

Arid and semi-arid lands: Generally, arid and semi-arid areas are characterized by poor vegetation cover with low level of diversity. However, this agroecology has its own adaptive ecology. For example, it has its own cattle breed while goats and camel are the main animals for the harsh environment. As observed in Somaliland cattle are shifted into highlands; goats and camels are surviving in the dry-land environment while sheep live near urban areas. Livestock size per family is reduced in Koneba near Dallol Depression. Moreover, agropastoralists are dependent on few types of short seasoned drought tolerance crops such as maize, sorghum, etc. Grass species are highly degraded and fields used to be grassland left with unpalatable grass species due to the recurrent drought caused by climate change. They are drought tolerance used as camel feed only. Moreover, dry land areas are dominated by invasive species such as prosopis and parthenium.

3.1.3. Climate change

Concerns about climate change are global and real (Ngaira, 2007) and its negative effects are global challenges. Third World countries, particularly Africa are threatened by the negative effects of climate change. The effects of climate change may include: reduced agricultural land-use; declining of agricultural production and productivity; biodiversity loss; increased aridity; frequent occurrence of extreme heat events; changes in rainfall distribution, drought and flooding (Serdeczny et al., 2016); increased incidences of farm pests and diseases, over cultivation, food insecurity and poverty especially in Tropical regions (Ngaira, 2007). According to the experiences of the crop-livestock mix farming of Ethiopia artificial fertilizer application in crop production combined with unreliable rainfall is a problem. As means of local adaptation, crop choice by farmers is becoming climate sensitive that they shift into drought resistant crops (Ramasamy and Hiepe, 2009; Ariel et al., 2012). Experiences in Tigray indicated that crops planted on fields applied with artificial fertilizer dry easily than fields applied with farm yard manure or compost (Hailu, 2010). Arid and semi-arid areas are characterized with harsh environment and they are aggravated by the effect of climate change mainly by drought and torrential flooding (Serdeczny et al., 2016). Therefore, human and animal lives are at risk during the rainy season.

3.1.4. Infestation of new types of insect, pest, disease, and weeds

These days in the face of climate change, new types of weed, disease, and pests are appearing and they highly affect crops, fruits and vegetables (Duressa, 2018) even grazing areas (Harnet, 2008). Prosopis (*Prosopis juliflora*) and parthenium weeds occupy large part of the grazing lands of the pastoralist and agropastoralist areas of the Horn of Africa. Although Prosopis is considered as a threat in agricultural areas at the same tiem it is also widely regarded as a useful resource for rural communities, which provides valuable resources as fire wood, timber, fodder; shade in hot climates, as wind breaks and/or stabilisation of sand dunes; extremely tolerant towards a wide range of climatic, soil physical and chemical factors (Harnet, 2008); its ability to regenerate sodic wastelands due to its survival rate and tolerance to soil salinity, low pH and water logging (Harnet, 2008). In Somaliland, it is the most important feed for camels and goats by which it seems access for animal based protein is dependent on the availability of prosopis (PELUM Ethiopia field report, 2018)) while a study by Harnet (2008) reported that pods are used in Sudan mainly for livestock fodder.

Production of crops becoming under risk due to Leaf and Fruit Spot of citrus (*Pseudocercospora angolensis*), Bacterial wilt (*Pseudomonas solanacearum*) of ginger, Tomato leaf miner of tomato (*Tuta absoluta*) and white mango scale insect (*Aulacaspis tubercularis*) damages mango trees. Yield loss in mangos due damage by insect pest can reach up to 95% loss in east Wollega zone (Duressa, 2018). Therefore, more investment in improving plant protection is needed to ensure long term food security of the region and establishment of strong quarantine to protect the entrance of new insect pests and diseases were highly needed in the country (Duressa, 2018).

The land areas being infested locusts and frequency of locust invasion is increasing from time to time in most part of the Horn of Africa. Livestock diseases are also problems in dryland areas while there is no proper access for veterinary service except their traditional medicine for human and animal sickness. Then many families are losing their animals due to animal disease.

There is no access for pesticides, insecticides and herbicides when needed but sometimes they are observed without any traceable source of origin and know-how on the proper utilization of these chemicals. For that matter mostly farmers apply these chemicals without any protection measures. At the same time there are lots of stockpiles of these hazardous expired chemicals available in different locations such as Koneba town near Dallol Depression (PELUM Ethiopia Field Report, 2018). Therefore, agro-ecological farming practice is the best way for the far to reach communities for human, animal, and environmental safety.

3.2. Sociocultural and economic challenges

3.2.1 Demographic challenges

According to the report of The Inter Africa Group (1995) the Horn of Africa (HOA) has unfavorable demographic dynamics that is high rate of growth; almost half of the region's population consists of those fifteen years of age or younger; this has led to serious overcrowding in the few cities, leading to a rapid deterioration in living conditions, including high unemployment, inadequate and squalid housing, poor urban services, and mounting crime. HOA is a challenging region to deal with conflicts with many unresolved political problems (The InterAfrica Group, 1995) with armed conflicts and fights for national interests generate unstable regional environment and community (Abdilahi, 2019); state violence, political repression, and protracted socio-political conflicts (Gebrewold, B., 2017). Solomon et al. (2018) stated that conflict has extensive negative impacts on the environment in the Horn of Africa with leading to grievances, resource scarcity and trans-border strife as well as internal migration and climate variability (Abdilahi, 2019) poor governance, environmental degradation and food insecurity, climatic disasters including droughts and floods, and lack of economic opportunities (Abdilahi, 2019).

3.2.2 Poor access to market

Regardless of the effect of climate change and push by the agricultural extension service providers, farmers are trying their best to increase production through diversification, intercropping, mixed cropping, vegetable production, agroforestry, etc. However, farmers lack market access and information. Then they are discouraged due to the low market price set by brokers. Livestock and livestock products (milk and milk products) are the most important resources and they see their animals more socially important than their economic values. They are reluctant in selling their livestock. If they want to sell they are dare to sell goats and sheep and rarely male camels. Socially and ethically selling female camel is not allowed. Arid and semi-arid areas are marginalized and they have poor infrastructure service supply that is they are poorly connected with roads, information, market, and remoteness to basic services. Therefore, they are not benefiting or earning the required income from their animal products.

3.2.3. Gender disparity

Gender disparity and poverty in Somalia is widespread (UNDP, 2012) with a significant pressure on women interconnected with other problems within the agriculture, pastoral and agro-pastoralist and socio-cultural. There isshortage of agricultural workers in areas of Somalia for cultivation (Osman et al., 2015); in South Sudan crop production cultivated by women-headed households (World Bank, 2013).

3.2.4. Poor access to water, human food, and animal feed

Arid and semi-arid areas are scarce in moisture availability. This part of the world is generally known as drought prone due to very low or no rainfall. Consequently, there is shortage of human food and animal feed. That is the main reason for the migration of pastoral people with their animals. Most of their cattle do not stay long around their settlement areas except small ruminant animals (goats and sheep). Malnutrition of children under five is on the rise due to loss and migration of animals. The flooding with big rivers flowing from nearby highlands is an opportunity to improve food and feed.

3.2.5. Free range grazing

The free range grazing culture in Ethiopia and in the Horn of Africa damages a lot in the vegetation cover. It also discourages many people started different agro-ecological activities because roaming of domestic animals during the dry season damage lots of newly emerged irrigation schemes mainly agroforestry by the name of free range grazing. In addition to this these domestic animals damage physical and biological soil and water conservation constructed during the dry season.

3.3. Political challenges

3.3.1. Land grabbing

Land grabbing is a very serious matter in Ethiopia. Big investment areas mixed farm practing highlands, in and around cities and in pastoralist and agro-pastoralist areas of Ethiopia. Investments not only grabbing large areas for different purposes such as sugar plantations in pastoral areas but also they are near to rivers, which break their access to water. Therefore, land ownership and access to water points are against the existing tradition practices of the pastoral people. Sometimes there is a correlation between arid and semi-arid areas with conflicts due to competitions for the available scarce resources.

3.3.2. Existing Policy

Due to the seriousness of the government on the food security issue, the attention of the agricultural extension services of Ethiopia is increasing agricultural production. Therefore, according to the government policy production increase is a top priority with a focus on high yielding varieties together with high external input. However, the government extension is trying to include low-external input (such as compost/ vermicompost) application and production with less attention.

3.3.3. Weak institutional capacity, linkage, and collaboration

This refers to all organizations or institutions implementing agro-ecology. These are: (1) academic institutions; (2) research institutions; (3) civil society organizations; (4) religious organizations and their affiliated institutions; (5) government sector offices. The aim of this category is to see what inputs are being used to enhance diversity, soil fertility or crop protection and how they training their students related to agro-ecology. The existing challenges in the institutions vary from each other. These are:

3.3.3.1. Lack of practical knowledge about agro-ecology

Although agro-ecology is an old complex practice by smallholder farmers for thousands of years in the Horn of Africa but professionals and policy makers do not know and recognize smallholder farmers as a system. Most academic and research institutions do not have proper connection and practical exercise to observe the rural farming system during their academic and research period. Enthusiastic young professionals are also challenged in communicating with farmers/pastoralists in the rural and they try to train farmers immediately after graduation without understanding the ground reality.

3.3.3.2. Poor institutional linkage

Almost all institutions lack relationship among each other to adopt good practice, reduce redundancy and their complementarity. This affected them building trust between the practices in the research and academics in one side and the actors (farmers and pastoral/agro-pastoralists) of agro-ecology in the other side. They are working their best to develop effective results in the research and knowledge base with less interaction with farmers. But at this time Ethiopian farmers are no more recipients.

3.3.3.3. Lack of resources for research and development

Academicians, researchers and civil society organizations raise the issue of lack of resources. These resources are required for research, capacity building and piloting projects. However, allocating resources for researches on agroecology are not easy in most of the academic and research areas while in reality it has strong mass base under low profile in this globalized world.

3.3.3.4. Designing of capacity building

In many research and academic institutions agro-ecological farming is not given much attention and researchers do not get back up by their institutions conducting research on agroecology. For example, whenever courses are designed in universities they focus competing with other universities at global level. Similarly, priority areas for researchers are given on the global crops having demand in the global market. Crops having local demand with local niche except teff do not get much attention. Then the qualification, quality and interest of the students lack employment opportunity and job creation at local level, etc.

3.4. Development challenges

3.4.1. Urban and peri-urban areas

Urban and peri-urban areas in the Horn of Africa in general and in Ethiopia in particular are characterized by limited but intensive types of economic activities in confined spaces. Urban agriculture supports many people but faces many challenges. Farmers in and around urban areas are threatened by urban expansion. Urban strategists do not see these farmers as contributors to the national economy.

3.4.2. Pollution and contamination of water, air, and soil

Urban areas are sources of lots of contaminants from residential and industrial areas. They contaminate water and vegetation and pollute soil and air. The vegetables and grasses grown in urban and per-urban areas are grown on contaminated soil with polluted water. Then they are used as human food and animal feed. Almost all the food staff produced around rivers and streams in and around urban areas is problems for health.

3.4.3. Urban waste

It is normal any growing city produces more and more organic wastes originated mainly moved from rural to urban as agricultural by products. It is a global problem. For most cities the disposal of wastes has become a serious problem. Peri-urban and nearby rural areas are unluckily used as damping locations for the urban wastes.

3.4.4. Rapid urbanization

Urbanization in the Horn of Africa in general and Ethiopia in particular is faster than its natural population growth through rural-urban migration. Its rapid urbanization growth requires adjacent land in the peripheries; then peri-urban farmers are displaced from their land and lack of working spaces for their agricultural activities. Therefore, rural areas are in danger of land encroachment due to urbanization and urban expansion. Then good farm-lands are eaten up mercilessly without proper compensation, which is called land grabbing. Consequently, farming societies are removed from their farming practices. They are also aligned with the growth of many social problems such as street settlers, begging, theft, etc.

3.4.5. Low policy recognition of agriculture

There is weak or no policy recognition for urban agriculture. Then the government does not give urban agriculture the required support and recognition throughout the Horn of Africa. For that matter it is only Addis Ababa that has Urban Agriculture Policy.

GOOD AGROECOLOGICAL PRACTICES

CHAPTER FOUR

SUSTAINABLE LAND MANAGEMENT BUILDS AGRO-ECOSYSTEM

Healthy soil plays a great role in protecting the health of human, animal and environment (Doran and Parkin, 1994). Healthy soil helps to sustain biological diversity and productivity, maintain environmental safety, and promote plant and animal health as it supplies nutrients in sufficient amount and balanced proportions required for optimum plant growth. It is directly related to biological productivity function; healthy soil and productive soil is necessarily fertile soil. Thus, soil must be both fertile and healthy to ensure its biological productivity function. Declining soil fertility is resulted into low crop productivity that research results indicated that most Ethiopian soils are deficient in nutrients (Mitiku et al., 2003; Fitsum, 2002) which are the main causes declining agricultural production and food and nutrition insecurity. For example, the average cereal yield at the national level is still low (Damte et al., 2020).

The Ethiopian agricultural extension service organization has focused on the application of artificial fertilizer (Urea and DAP), only support available nitrogen and phosphorous. However, applying these two nutrients are not enough to reverse the production problem. Even excess use of artificial fertilizer or compost may result into the development of soil salinity (Wudu and Mahider, 2020). However, many research results reported that agro-ecological practices such as applications of compost, manure, crop rotation, intercropping, complementing artificial and natural fertilizer, etc. (Hailu, 2010) achieved soil fertility and soil health problems and enhance productivity. Some of the examples mentioned below are evidences showing there is no marginal land in agro-ecological practice and it can defeat marginal land or dryness.

4.1. Konso: The land of home-driven Integrated Soil and Water Management Practices

The name Konso belongs to the people and the land where they live in southwestern Ethiopia. It covers highly degraded and rugged terrain with little available flat land. Farming is the main source of livelihood with average land size between 0.9 and 1.5 ha with average cereal production is 0.5 and 0.3 t ha^{-1} (Hailu and Yohannes, 2015) and lack of moisture (Tesfaye, 2003). The following are agro-ecological practices of Konso.

Integrated soil and water conservation Practice (ISWCP)

Soil and water conservation practice in Konso is marked by the combination of physical and biological conservation measures. These include: stone terraces, tied-ridges, thrash lines, agroforestry, intercropping, fallowing, manuring, Kraal shifting, burning of debris and minimum tillage. The use of stone in both fields and residential areas is their tradition (Tesfaye, 2003). Bench terraces made of stones in Konso contributes to infiltration of raindrops and decrease or stop soil erosion. Farmers of Konso import more soil and organic matter in the thrash lines. Women play a great role in transporting manure from the villages to the farms (Hailu and Yohannes, 2015; Tesfaye, 2003).

Figure 2: Landscape of Konso around Karat town

Farmers in Konso have an amazing appreciation for stone terraces that helps conserve soil, retain waterin the field, serves as a support to climbing crops such as lablab, makes hill farming possible, increases soil fertility; and which ultimately helps in increasing production. Terracing is a normal indigenous practice for Konso people and it existed for the last 500 - 800 years. Their efforts are registered as one of the world heritage sites by the UNESCO (Tesfaye Beshah, 2003). The main features of the Konso indigenous soil and water conservation practice are:

- **Square terrace farming**

The integrated soil and water conservation system includes thrash lines that combine square terraces (Figure 3) with mulch, which are used as source of organic matter. Thrash-lines are plots divided into squares supported by mulch of maize and sorghum stalks including all kinds of biomass that are uprooted during the dry season and left in the farm. Using thrash lines is very important for effective moisture conservation and water-harvesting structures in dry valleys from flood water coming from surrounding highland areas. It was witnessed that there was sufficient moisture during dry season (Hailu et al., 2015) for the growth of cereals such as teff and sorghum B and C of Figure 3.

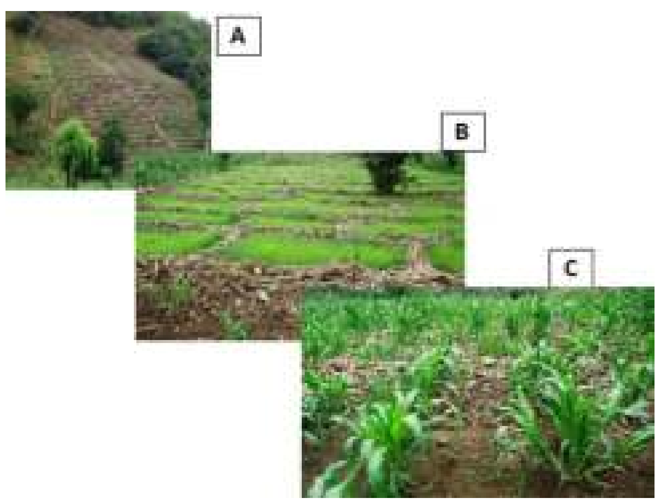

Figure 3: Hillside squared terraces supported by mulching (A); Teff field in mulch and squared terrace (B); and Sorghum field in mulch and squared terrace (C)

- **Cropping pattern and agroforestry**

Agroforestry is a typical feature of the hoe-farming system in Konso characterized by multiple cropping systems with multiple uses. The dominant high tree species is *Moringa* because its leaves are important in the people's daily food followed by *Terminalia browenii* grown for forage, farm tools and building materials. The next cropping pattern is filled by crops such as coffee, chat (*Catha edulis*), yam, cassava, pigeon pea and cotton. Cereals are often intercropped with pulses (haricot beans, pigeon peas, lablab, peas, chickpeas and cowpeas), among others, for risk aversion, soil fertility and land saving (Tesfaye, 2003).

Mixed and intercropping pattern help to ensure the availability of food from different crops and obtains animal feed by thinning the field crops and maintain soil fertility in their plots. In general, one can count 10-15 crops in a field in addition to big high tree. The general pattern of crop association is a mixture of cereals with pulses. A cereal-cereal pulse arrangement takes place if there is good fertility of the land (Hailu and Yohannes, 2015; Tesfaye, 2003). Some crops are drought tolerant (sorghum, cotton, pigeon pea), while others (e.g., haricot bean) are early-maturing. Inter cropping helps minimize risks from moisture stress and give soil coverage. Intercropping also helps farmers make better use of their limited land and scarcity of labour (Hailu and Yohannes, 2015). The area is conducive for production of fruit trees like lemon, orange, guava trees, banana and papaya. Crop diversity, in a seemingly hostile environment also favours the growth of coffee. The ritual practices and traditions in the society also call for the growing of chat and tobacco.

- **Maintaining soil health and fertility**

The major sources of organic matter in Konso are manure, household refuse, pulses, leaves and branch of tree and thrash lines. Manure is obtained from animals raised at home and from the community garbage square, located outside the village fence, adjacent to the traditional *Dina*. It is normal to see a Konso woman travelling every morning with some organic matter to fertilizer their fields (Hailu and Yohannes, 2015; Tesfaye, 2003). Farmers who own cattle and labour, practice kraal shifting. Minimum tillage is highly practiced in Konso carried out every second or third year by simply uprooting the sorghum stalks in the dry period and then cultivate (without tilling) the land during the rainy period for sowing.

Livestock production has been part and parcel of Konso*'s* mixed farming system for the purpose of manures and savings. There is a system of animal sharing whereby poor families can obtain access to livestock in order to access to manure. Konso people strictly keep their animals away from the crop fields in accordance with the developed rules and regulations for the purpose of protecting their integrated soil and water conservation system from being damaged by animals.

4.2. Integrated soil and water conservation in Hararghe

Hararghe highland is one of the highly degraded landscape areas of Ethiopia. More forest and grazing lands have been converted to crop land and marginal land or steep slopes were ploughed, which aggravated soil erosion. Sedimentation resulted from severe soil erosion in the highlands of Haragie is one of the causes for the drying of Lake Haromaya "as one evidence" (Muleta et al., 2006). Consequently, land productivity has declined and then human and animal survival is highly impacted.

In an effort to overcome the problem integrated soil and water conservation technologies were introduced to the area in the 1980s (Abbadi and Nitin, 2010) and the technologies have changed the attitude of the communities, the economic and environmental landscape of Hararghe. It has reversed soil erosion, improved soil fertility, and farm land management, and also enhanced the production and productivities of crops. The physical and biological SWC practices provided soil with a stable cover of crops fruits and forage for long period as possible during rainy season especially at time of heavy rainfall.

Figure 4: From community mobilization to effective SWC in Hararghe

Area closure which involves excluding or closing degraded land from animal and human interference was another SWC technology which was introduced to the communities has rehabilitated the degraded and turned it to be productive. It controlled soil erosion and improved soil fertility; reduce runoff and percolate underground water recharges; resulted in degraded land rehabilitation; and had ecological, economic, and environmental advantages. For instance, the spring water are back, land become productive especially the huge amount of fodder crops that planted before few years were used for animal feed as cut and carrying systems, beekeeping introduced and grasses for house roof cover, for recreational site and also used as wild life sanctuary to return. As a result of these all integrated activities this part of Ethiopia is known for animal fattening through cut and carry method (Daniel et al., 2017; Hiwot et al., 2016 and unpublished field report, 2017). Farmers are becoming resilient due to increasing land productivity, biodiversity conservation, creating ecological balance and economic backup. Ultimately, re-greening improves energy, food and water security and will contribute to poverty alleviation by ensuring sound basis for economic development and human well-being (Giessen, 2011).

Figure 5: The ecosystem benefits from SWC

4.3. Abreha We-Atsbeha: “There is no marginal land under agroecological practices”

Abreha We-Atsbeha Kebele is a village named after an ancient church which was established back in the 12^{th}C and dedicated to the first Christian emperors of Ethiopia. Most of the soils in the area are very sandy with poor water holding capacity. Due to severe land degradation problem occurred in Abreha we-Atsbeha village, in the early 1990s the local people asked the government to find them a place where they could move and live. But later the community changed their mindset and insead of migrating to another place, they came together to discuss and find solutions to the fatal land degradation problem they faced. After discussion they decided to heal their land through reclaiming gullies and rehabilitate degraded hills in order to live in their home area (Hailu et al., 2012).

Figure 6: Aba Hawi welcoming and explaining to visitors about Abreha we-Atsbeha

Aba Hawi, the ex-leader of the community follows principle of "*Do not plant trees if the survival rate is going to be low* …. Why *worry and spend a lot of time, money and labor while our mother nature is generous? Our [tree] survival rate is higher than anywhere else in Ethiopia.*"

Figure 7: The impact of integrated watershed management in Abreha we-Atsbeha with the steep hills covered in vegetation and a large permanent pool along a river surrounded by trees and shrubs

All the improved practices in Abreha we-Atsbeha village are based on work with an impact on improved food security for the community. Now, there is no erosion or violent run off in the whole valley. Water is retained by the physical structures so that it seeps into the ground and recharges the sub-surface ground water. There are even permanent streams and pools of water (Hailu et al., 2012).

Due to their restless efforts, now there is sufficient water in the valley for micro-irrigation throughout the year with many farmers developing vegetable gardens and fruit orchards. Another success is the change from free range to zero and controlled grazing land to feed their animals and to support the natural resource conservation work through the increased biomass. This also gave a chance for other community members, particularly unemployed and landless youth, to develop beekeeping groups. Now this village is a model in the whole of Tigray for its exemplary restoration and conservation work. In June 2012, Abreha WeAtsbeha received The Equator Prize at the Rio+20 World Summit on Sustainable Development in Rio de Janeiro. It is also one of the models for the 2016 Global Gold Future Policy Award of World Future Council.

4.4. Socially enhanced and community managed hillside development

Ethiopian mountains and highlands covered 45% (Hurni, 1993), where many people live like study area called Kacha Bira in SNNPR State. The traditional farming practices employed on steep sloppy lands have many challenges. The major challenges are scarcity of water for both human and livestock; soil erosion, deforestation, low crop productivity, crop pests and diseases, weeds, inadequate access to markets, lack of access roads, etc.

Government has been trying to regulate for an effective watershed management by issuing different policies and strategies. However, it has been reported to be unsustainable. Nonetheless, the elders and commnutiy leaders took the intitative to mobilize community, held series of community conversations, and secured consensus among the community to deny social status and any social service upto expelling the farmer from Community Based Organization (CBO) called Idir if he/ she fails to do the terracing on own farm and/or take part in the same practice on communal land. The terracing management approach chosen was innovative and intended to be local driven as bottom-up within the existing government structure.

With the community taking ownership and playing the lead role of the overall development program, all community conservation works were properly protected and maintained resulting in reduced soil erosion. Terrace farming is a major source of livelihoods for a large section of hillside farmers. The hilly or mountainous terrains are divided into narrow but graduated steps, typically 2–3m wide and 50–80m long across the slopes, to facilitate growth of field crops, horticultural crops, fodder, and other crops that require specific management practices alone or in combination with agroforestry trees.

Figure 8: Community owned land management in South Central Ethiopia

Physical conservation measures implemented in the areas included hill side terrace construction, farm land terrace construction, bench terracing, terrace maintenance, check dam construction, bund stabilization, gully rehabilitation, trench construction, small scale dam construction, micro basin, eye burrow basin, improved pits, cut-off drains; hand dug well construction, trapezoidal water tanks, and plastic bed water harvesting ponds. Biological measures included compost preparation, pitting and planting, area closure. Some of the interventions under the natural resources development and management sector include soil and water conservation on different land cover or uses, agro-forestry development, gully rehabilitation, closed area management, afforestation, training farmers, etc.

The terraced lands were converted into a well-managed bench terraces with elephant and Vetiver grasses, Sesbania, Pigeon pea planted on bunds for forage production and bund stabilization. In these areas, yields of crop performance improved in the terraces. In the *Dorebo* watershed of *Kachabira District*, terrace farming showed increased yields of wheat and barley due to the Soil Water Conservation and erosion control, resulting in improved household income and food security. Those farmers who have constructed water harvesting structures have started production of vegetables and fruit trees, mainly apple. As a result, communities are able to control soil erosion, increase their product and family income, added to the beauty of the scene in the area and bring all rounded wellbeing among communities.

Figure 9: Multiple benefits of sustainable land management

4.5. Pastoralist and agro-pastoral managed natural regeneration

Pastoral and agro-pastoral areas are challenged by shortage of water, animal feed and health problems due to climate change, mainly drought. The main types of domestic animals are goats, sheep, camels and cattle but are shifting to climate adapting domestic animals which are camels and goats. Cattle and sheep are decreasing from time to time. In some locations pastoral people are adapting agropastoralism that is growing fruits, vegetables, crops, mixed farming, etc. This is due to using water from devastating floods from nearby highlands. Another source of water is use of seasonal river-beds such as around Hargeissa area of Somaliland. Additional challenges of economic activities of drylands include prosopis and parthenium infestation; insect and pest affect vegetable growing and desert locusts also damage the crops and any animal feed. Pastoral and agropastoral communities of the region excercises different practices in a bid to cope some of the challenges that the face in these course of their life. Some of locally accepted key practices observed are:

- **Adapating to selected animals:** Many pastoral communities are forced to: first, reducing the number of domestic animals per household; second, shift to limited type of domestic animals, which adapting to drought and/ or travelling long distances without water such as camel and goats; and third, feed their animals in small quantity or browse in unpalatable plants. For example, most of the domestic animals around urban areas in Somaliland are browsing on acacia and prosopis trees. This means this plant is very important for goats, camels and even for sheep (PELUM Ethiopia field assessment report, 2017). Therefore, these communities are nearly deficient in animal sourced food types.
- **Seasonal migration:** The common practices in all pastoral areas help minimize risk of animal death by migrating seasonally towards areas where water and animal feed are available. For example, pastorals of Kereyu areas of East Shewa migrate with their camel as long as Kembata Tembaro area (Southern Ethiopia) along the Rift Valley in search of animal feed and water. People in Somaliland migrate to the highlands of east of Hargeisa. According to pastoralists, migration is one of the best ways to feed and water their animals. However, that divides the family to migrate while elders, mothers, children and unhealthy stay in their localities with small number of cattle for milk and meat production.

- **Growing their own animal feed:** Pastoral and agro-pastoral areas are also growing forage through irrigation where water is available. This helps them minimize the risk of their domestic animals from being swiped due to drought. The good practices of pastoral and agro-pastoral people in Bada area of Dallol wereda use flooded water to grow animal feed. The other practice is rangeland rehabilitation i.e. a project by Candlelight of Somaliland. They dig surface water harvesting trenches in the plain lands. There are signs of success i.e. smaller bushes in both sides of the trenches are greener than their surroundings with bushy grasses. It was over 800ha in size. The same is also practiced in many families of Koneba District near to Dallol. In addition to fencing they divert flood water into their fenced plots.

Figure 10: Landscape, vegetation cover and animal grazing in Somaliland

Figure 11: Rangeland rehabilitation in Somaliland by Candlelight Somaliland

- **Community managed natural resource regeneration:** Area closure, locally called Kelela in Zone Five of Afar Regional State, is good with reduced number of cattle. '**Kelela'** is a common term used to describe, fencing a grazing land with stone and thorny trees in which no one is allowed to graze the land. It will be just protected, in the rainy season the grass will grow in it, andthe trees are also protected. Mohamed Ahmed Bertalo is living in Aydelhangeg Kebele of Simurobi Wereda in Afar Region. He is a pioneer in using this method, at the start he was challenged by the community because communal approach is their normal life style. Like many other people, he used to suffer during the recurrent drought as any pastoral due to climate change. He lost some of his cattle. He preferred to be challenged by his community than challenged by the drought/climate change. After his fenced space was rehabilitated he showed its importance to the people in the community by allowing their weak animals feed into his protected land.

During the 2015 and 2016 drought unlike others he moved nowhere, he used the 'Kelela' for his livestock and his cattle survived with no death starting from this innovative idea. Then he strengthened his Kelela and some other families are now following his foot print. Even though it is not accepted by the local communities to own Kelela by individuals, it is spreading throughout Afar.

Figure 12: Mohamed Ahmed guarding his Kelela (area closure) Semurobi Gela'elo, Afar Region of Ethiopia

4.6. Live fence and terraces

The soil conservation works in Ethiopia involve physical and biological conservation methods, which include terraces, trench bunds, biological plantations, etc. For many years in various rural parts of Ethiopia terraces and soil bunds used to be built on sloppy and exposed to soil erosion farm lands. However, the success of the estabilishment of terraces and bunds were limited. One of the reasons for the failure of physical soil conservation structures to establish is that domestic animals are allowed to graze freely during the dry season they destroy the structures. At the same many innovative farmers who started planting different fruit trees and vegetables are highly suffered and discouraged due to the free range grazing. But fortunately with time, some people introduce their own innovative and effective ideas to benefit best out of their farming system. For example,

4.6.1. Planting of gesho on terraces and trench bunds

The planting of different useful plants in farmlands or as border plants such as "Gesho[4]" is one of the most effective and well accepted economically useful plat by many people because gesho is not eaten by most animals and it is good source of income. Two good examples of this practice are in Mai Berazio of Tahtai Maichew around Axum and one farmer from Mota East Gojjam. In addition to maintaining the old terraces built on their farmlands it generate income from selling the leaves as a supplement to their income obtained from crop yields.

Some farmers who live inside a watershed share their innovative experiences and planted gesho in their farm boundaries and terraces. For example, Mr. Sileshi Assefa, Mota area of East Gojjam, is one of the farmers who shared his experience for the participants during the visit. He is one of a farmer who planted Gesho and

[4]Gesho is herb/shrub also called Rhamnus prinoides used for making traditional drinkng such as tella and tej made of grain and honey respectively.

fruits (Mango, Orange and lemon) on terracing land at Tedima watershed since 2013. According to Mr. Sileshi, he has earned 20,000 birr in 2013 by selling Gesho only to the market. Mr. Sileshi said that '*it is my pleasure to be a farmer who has a vision to see my family members to be food secured as I would like to extend plantation of fruits and vegetable since it enables me to diversify my income.* The synergy created by the gesho and the terrace are bringing good opportunities for their farm such as moisture retention and animal fodder increased. He also thanks his family members for their great contribution for farm activities during the plantation and harvesting of Gesho and other fruit and vegetables. Mr Sileshi forwarded his recommendation for farmers who participated in the field visit to follow his practice.

Figure 13: Ato Sileshi with his *Gesho*

Many visitor farmers adopted this practice to many places as part of their Integrated Natural Resource Management activities; plant Gesho on their farm lands as intercropping, on conservation structure and their garden areas after they have returned to their home.

4.6.2. Beles: Multifunctional plant for true agrocological practice

Beles (prickly-pear) grows well in most part of the Horn of Africa mainly in Eritrea and Ethiopia. In Northern Ethiopia is well grown and used in Eastern and Southern Tigray Region. It grows around homesteads, farm boundaries, hillsides, etc. It is multifunctional plant for these people especially for people in the Hintalo-Wejerat and Mehoni Districts.

During the rainy season, it is a source of human food for about six months (from June to November). When consumed by human, it does not require more supplement like sauce, spices, salt, etc. During the main rainy season, it generates a lot of income for many families. It is also a good source of animal feed in most dry periods with full of moisture in the stem of Beles. During the 1984/5 Ethiopian Drought, it has saved millions of animals because it is one of the most known succulent and moisture stress tolerant crops.

As it creates good synergy with ecosystem services it serves as buffer zone for their crops. For example, Kes (Priest) Abreha Hagos of from Hintalo Wejerat said "It was serving us as a very good buffer zone or fence against many raider wild animals such as baboon." Beles areas were known for more vegetation type and density than the nearby non beles areas. It is a very rich organic nutrient source for plants which grow under its canopy. Thus, beles undergrowing plants or plants that grow below beles don't require additional nutrient inputs.

Figure 14: How beles is useful in many ways (source:- http://jhodgesagame.blogspot.com/2013/12/cactus-fruit-aka-beles-or-prickly-pear.html)

However, now Beles plant population and production of Beles is decliningdue to its infestation by cucheanel insect pest. This insect pest has damaged lots of fields and still continues damaging in many other locations almost all forms of Beles. Consequently, Beles as source of food and feed decreasing, its service as a buffer zone i.e. Kes Abreha Hagos from Hintalo Wejerat said “Now I realized that in the early time when Beles was good baboons were enjoying with the fruits of beles than coming to our crops. Now we are suffering because the baboon raiding to other crops. It has reduced vegetation cover and soil fertility.”

CHAPTER FIVE

ECOLOGICAL AGRICULTURE IS THE BEAUTY OF DIVERSITY

According to the report by IPGRI (2005) in the world at least 7,000 plant species could be cultivated for food, but only 150 crops are grown commercially. Ethiopia is one of the countries of great geographic diversity, and macro- and micro-climatic variability over the wide altitudinal variation. It possesses an estimated number of 6000 species of higher plants of which 10% are endemic. There are 75 breeds of cattle, sheep, goat, and equines, six species of honey bees, etc. The country is also believed to harbour a wide diversity of microbial genetic resources (EBI, 2014). However, they are facing pressures resulting in severe deforestation, overutilization, soil erosion and desertification; and eventual loss of natural habitat, species and breeds (EBI, 2014). Some one can find lots of species in a small area. For example, study reports indicate that there are 59 aromatic and medicinal plants, 4 traditional vegetables, 16 spices, and 14 traditional fruit trees in Tigray Region (Fetien and Sara, 2008); Gebremedhin and Muluberhan, 2007). These studies indicate that the local communities have an extensive knowledge about their wide uses based on the experiences tested over centuries; adapted to the local culture and environment; embedded in community practices, institutions, relationships and rituals; held by individuals or communities; and remain dynamic and changing (Zemede and Mesfin, 2001; FAO, 2004; Gemedo Dalle, Maass and Isselstein, 2005). This indicates there ere exist different types of biological diversity in an eco-system. These are:

5.1: Agro-ecology is the source of seed diversity

Agroecological diversity is beyond farming reflected above and below ground. It is not only diversity but also a beauty of the ecological systems. Distributions of diversity are reflected in the environment, socio-economicsystems, etc. but vary across agro-ecological zones. Table (2) shows the distribution of the major crops in the Horn of Africa. Their distribution is changing from time to time due to the effects of climate change. Diversity is wide throughout the rural Ethiopia i.e. at home, in the farms, in the market, etc. Rural mothers have a lot at hand to feed their families only after securing seeds. The seeds are not only different by their type but also by their variety, socio-cultural importance, color, flavor, etc.

Table 2: Agro-ecological diversity and their distribution

S.N.	Major crops	Highland areas	Humid and sub-humid areas	Arid and semi-arid areas	Urban and peri-urban areas
1	Cereals	Tef, maize, wheat, barley,	Maize, sorghum, millet, rice	Maize, sorghum, millet	Not a focus
2	Pulses	Faba bean, field pea, chick peas	Beans		Not a focus
3	Oil crops	Niger seed, safflower,	Sesame	Sesame	Not a focus
4	Fruits and vegetables	Varieties (there is no special) traditional vegetables like pumpkin	Varieties (there is no special) traditional vegetables like pumpkin	Varieties (there is no special) traditional vegetables like pumpkin	Seasonal vegetables around river sides and peri-urban areas
5	Root crops	Potato	Enset, taro, sweet potato		
6	NTFP	Beekeeping, herbs,	Beekeeping, spices, coffee, bamboo, herbs,	Beekeeping, herbs,	
7	Livestock	Cattle, sheep, goats	Cattle, goats	Cattle, sheep, goats, camel,	Poultry, dairy and fattening

The reality under climate change and globalization indicated crop diversification is under threat. However, farmers never give-up as they have coping strategy. The decline and shift in agro-biodiversity is due to the negative effects of climate change i.e. occurrences of drought and unreliable rainfall. However, farmers adjust their seed demand depending on the changing situation. For example, first of all, they prepare seed for the normal season i.e. finger millet, sorghum, maize, etc. for April or May but if the rainfall fails to come in time they do not fail and sit. Instead, they look for another seed option (teff, barley, legumes, wheat, etc) based on their localities to be planted during June or July. If again the rainfall failed as planned, they plan for very short season crops to be planted in September as their last resort. This is the lifestyle in agroecological society.

Moreover, farmers shifted to the improvement of soil health and fertility, soil organisms and crop diversities to sustain the diverse seed system. This is because local seeds and inputs are accessible, cheap, affordable and easy to understand.

As the Horn of Africa Region is drought prone especially those with shallow soils, crops planted with external input wilt faster than the crops planted with compost or animal manure (Hailu and Edwards, 2006; SSNC, 2008). Using compost, manure, and mulch solved problem that may happen due to the early cessation of rain. Farmers realize the role of compost in sustaining yield and improving the soil (Ouedraogo et al., 2001). Maintaining or increasing agro-biodiversity; for example, Zeban Sas was growing wheat and barley mixed together with a little teff, but now other crops like maize and faba bean are also grown (ISD report, 2004).

Table 3: Sources of seed in some selected communities for the year 2003 harvest

Sources	Teff	Wheat	Barley	Karka'eta[5]	Maize	Sorghum	Millet	Pulses	Garden	Total
Personal	16 (43.2)	22 (53.7)	20 (52.6)	2 (13.3)	24 (50.0)	9 (64.3)	1 (5.3)	22 (48.9)	9 (29.0)	125 (43.4)
Neighbor	4 (10.8)	5 (12.2)	2 (5.3)	1 (6.7)	8 (16.7)	1 (7.1)	15 (79.9)	5 (11.1)	6 (19.4)	47 (16.3)
Local Market	12 (32.4)	1 (2.4)	16 (42.1)	12 (80)	13 (27.1)	4 (28.6)	3 (15.8)	15 (33.3)	12 (38.1)	88 (30.6)
Improved Seed	5 (13.5)	13 (31.7)	-	-	3 (6.3)	-	-	3 (6.7)	4 (12.9)	28 (9.7)
Total	**37 (12.9)**	**41 (14.2)**	**38 (13.2)**	**15 (5.2)**	**48 (16.7)**	**14 (4.9)**	**19 (6.6)**	**45 (15.6)**	**31 (10.8)**	**288 (100.0)**

Source: Questionnaire; Numbers within brackets are percentages

Moreover, the existing practice of seed saving and exchange at local level is very adaptive to the present climate change that over 90 percent use and exchange seeds from local sources (Table 10). This is because the informal seed sector is the most adaptable to the growing area. However, there are many local knowledge and practices to maintain the seed and food sovereignty of the country at large by saving, storing and using Ethiopian agro-biodiversity. These cultivars are more tolerant to drought, pests and diseases than the improved varieties.

5.2: Root crops and homestead garden

There are many types of root crops in Ethiopia eaten raw or cooked. Some of the domesticated and frequently used are potato, enset, sweet potato, taro, etc. but there are many wild edible plants in most parts of the different agro-ecologies throughout the Horn of Africa especially in Ethiopia. Most of the spices are grown around homesteads (Temesgen et al., 2016).

The most important spices are found in the highland and the humid and sub-humid areas of Ethiopia. In the highlands they are deliberately planted in the right season while in the humid and sub-humid areas, they grow as wild plants in the nearby forest areas. Everywhere women are responsible for planting and caring of spices. For example, according to the study conducted in some districts of Tigray by (Fetien and Sara, 2008) about 17 different types of spices used by women are: basel, garlic, fenugreek, *Chena Adam*, onion, *Tselim Kimem*,

[5]Also called *hanfets* “a deliberately mixed crop of wheat and barley.”

Awesda, *Kamun*, *Azmud*, *Senafich*, *Shinfae*, *Tesne*, *Mokmoko*, ginger, Green peper, *Dimblil*, etc. The most commonly used spice are basel, garlic, fenugreek, Chena Adam and onion for 84.54%, 54.64%, 49.48%, 42.27%, and 37.11% of the respondents respectively use these plants (Fetien and Sara, 2008).

The analysis shows most of the spices are commonly used in all the study woredas. It is also almost similar throughout the Ethiopian highlands. But the most common spices in the humid and sub-humid areas of Ethiopia are different. These are: Local – senafich, besobla (basel), kundo berbere, ginger, tamarin, korerima (Ethiopian Cordamom), shinfae, Long pepper (Timiz), Black pepper, Lima Bean, Grain Amaranthus (Katila), Turmeric, 'Gesho' (Rhamnus prinoides), banana, rubber tree, etc. Most of these spices are found in the forest. There are limited types of spices like ginger grown around homestead areas as source of food and income.

Special crops in Benishangul Gumuz

There is an opportunity of using fast maturing emergency crops i.e., it is called ***adihun*** exist in Kurmik, Menge, Sherkole, etc areas of Benishangul Gumuz. It was lost but regained in collaboration between the Regional Biodiversity Institute and the local community (Unpublished field report, 2017). Now, it is ready for scaling up as emergency crop. It matures in 45 days. Its leaves are matured enough for eating within 2 weeks and the tuber part in 40 days. It needs only about a liter of water to mature by drip irrigation for 20 days only. After 45 days this plant becomes matured for harvest.

Another crop is Pearl millet, which grow well in the Southwest of Ethiopia. It is very important and matures in 45 days and escapes thechallenge of weed such as striga due to short growing period i.e. before the this weed dominates the crop. Traditionally, Amaranthus (Katila) is also grown and highly used in the Humid and Sub-humid (South West) part of Ethiopia. Pearl millet and amaranthus are nutritious and the local people use them as soup/ porrage.

5.3: Traditional agroforestry

Gedeo indigenous agro-forestry System is 5,000 years old (SNNPR Report, 2002), which is one classical example of agro-ecological farming practice in the history of Ethiopia. Wild coffees are grown naturally in combination of indigenous trees like; *Cordia africana* and *Acacia abyssinica* as well as other forest tree species. They sustained and preserved their natural landscapes and culture through their traditional administration called ''Ballee'' system that is through the domestication of natural forest and intensification of agriculture. The indigenous agro-forestry system is found on the fragmented mountains and hills along the rift valley escarpments and more than 69% was found on very steep slopes which can be best example for densely populated, rugged and mountainous landscapes. They can teach others on how to harmonize population pressure with sustainable production and conservation and manage a watershed in rugged landscapes.

Moreover, there are many good agro-forestry areas and villages in all regions of the country. For example, W/ro Tekle Gidey of Enebse Sar Midir in East Gojjam and W/ro Medhin Gereziher of Tahtai Maichew in Tigray have exemplary orchard with fruits, vegetable and spices. Mr Tilahun Teka of Wendogenet dominantly agroforestry mixed with coffee and enset completemented by bioslurry application. Agro-forestry mixed with chat in Wollo and Harar. Many churches and monasteries are also good living examples. All traditional agro-forestry mentioned here contains between 25-35 types of plants within their 0.125-0.25ha of farm. These smaller farmlands feed families successfully even they generate assets out of their activities. This shows us that land size is not determining factors to be rich or poor as there are many people with bigger land but they are one of the poorest people while some others are rich not because of their land but their efforts (Hailu and Yohannes, 2017).

These days, there is notable increment in the recognition of the significance of indigenous knowledge in sustainable development in the developing world (Warren, 1991). In agro-ecological farming practice, indigenous knowledge provides opportunities for environmental conservation, improvement of livelihoods and well-being of rural communities, and contributes to the national economies (Madeley, 2002).

5.4: Intercropping, mixed cropping, and ralley cropping

Inter-cropping, mixed-cropping, and ralley cropping are old practices that increase the nutrition and income of families in different parts of Ethiopia. It maximizes output per unit area by applying non-competing crops for an extended period. For example, when some one plants tomato in a teff field, it can be used till April or May continuously. It also minimizes the risk of crop failure such as the growing of Hanfets/ Karka'eta (a mixture of barely and durum wheat) in Eastern Tigray (Hailu and Yohannes, 2017). Moreover, these crops are good source of seed.

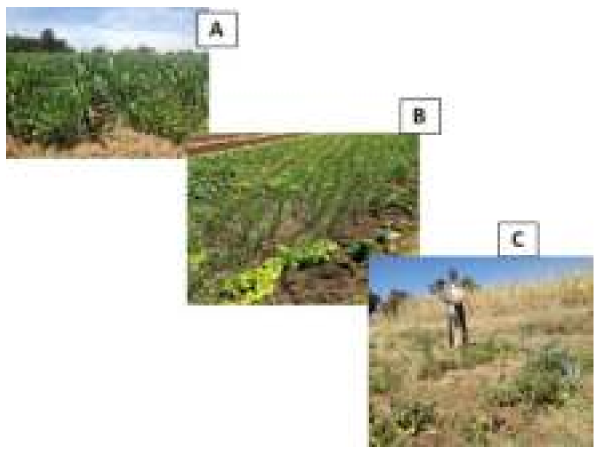

Figure 15: Intercropping of: Maize with bean (A); lettuce with onion (B); teff with tomato (C) shown by farmer Haleka Gidey Hagos

Haleka Gidey (see part C of the photo below) has grown tomato (*Solanum copersicum*) with teff (*Eragrostis tef* (Zucc) and Niger seed with teff. The emergence and growing patterns of both teff and tomato were different. The main crop (teff) harvest took place when the crops reached maturity. However, the tomatoes remained green and grow continuously and it is harvested continuously.

Figure 16: Experience sharing visit of farmers from East Gojjam to Central Tigray guided by farmer Abadi

Intercropping is also a preventive measure of cultivation practices as crop losses are reduced while yields increased by intercropping teff and tomato, Niger seed and teff varieties that are high value crops. Moreover, plant diversity creates overall plant health; reduce pest pressure; increased insect pest and disease resistance of crops; increased insect predator populations; increased weed suppression; sustainable soil-plant relation with nutrient circulation and natural soil tillage. It also increases the activities of soil microorganism which increase yield of involved crops and better use of cultivated land.

5.5: Enset: the mother of millions in the face of climate change

Enset is an economically important food crop in Ethiopia. It grows most in densely populated as a staple food in Gedeo, Sidamo, Gurage, Hadiya, and Kembata zones; as a co-staple food crop in Wolayita, Gofa, Keffa, Amaro and Yem zones; and as supplement to cereals in Welega, Jimma, West Shoa, Illubabor and parts of Kefecho zone *(Shank and Ertiro,* 1996). This indicates enset is a good example of diversified agroecological practices in many part of the country.

According to Shank and Ertiro *(*1996), the cropping system and current food security/nutritional situation of enset are: Enset/Coffee/Maize Culture of Sidamo-Dilla; the Enset/Maize Culture of Jima-Mizan Teferi; the Enset/ Root Crop/Maize Culture of Wolayita-Sodo; the Enset/Livestock Culture of Dawro-Waka; complex intercropping at Kacha Bira Wereda, etc. These days, the intercropping pattern is becoming very much diversified than years ago. For example, Ato Weldehana Aalibore Afacho of the Doreba kebele of Kacha Bira Wereda in the SNNPR; his community practices integrated farming activities on enset, coffee, apple, barely, wheat, beans, chickpeas, spices, potato, home garden and cattle.

Figure 17: *Enset farm around homestead*

Enset is very high yielder; it is multifunctional role in the livelihood of the community that once harvested it can be used to make several kinds of foods (Daniel, 2010). It is a source of food and fodder, fiber, herbal medicine and source of income. It holds moisture and restricts soil erosion. Precisely, all parts of enset are useful. The varieties of uses coming out of the crop is directly related to the fact that **enset** the main crop of the people that utilize it throughout the year (Yemane and Kibebew, 2006).

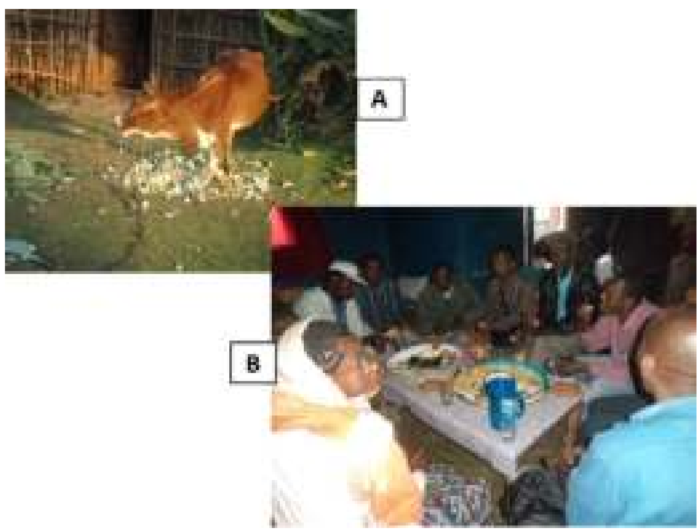

Figure 18*: Enset as anima feed in Aleta Wendo area **(A);*** human food (B) at Kacha Bira

Planting enset is good to cover land with green vegetation. The moisture kept in the soil by the deep roots of the plant give it greater resilience to drought than can other cereal crops have. Consequently, the people who grow it retain a greater degree of food security. Fertility of soil underenset plantation areas are improved due to the long-term application of manure, compost, mulching of leaf and stem residues. It has good connection with animal and their manure. Enset plants also provide important windbreaks and serve as a shade from direct sunlight. Enset is also a good plant to inter-crop with coffee, potato and other food crops, which benefit from shady growing conditions.

5.6: Non-timber Forest Products (NTFPs)

The Horn of Africa in general is endowed with the most diverse flora and fauna. The higher floristic diversity of Ethiopia provides a variety of NTFPs of various uses, which include gum acacia, frankincense, myrrh, spices and condiments, traditional medicine, wild honey and beeswax, bamboo, wild palm, wild food, fibers, tannins and dyes, latex, thatching, wild edible and non-edible products, essential oils and aromatic plants, and insecticides. However, in some locations they are the main income generator but these days they are highly affected by widespread deforestation, wild fire, investment, etc.

The main NTFPs are:

Tree based products:

Gum and resins is high in Ethiopia, Somalia (Somaliland) and Sudan. Forest coffee, in South-western Ethiopia is the home and origin of the coffee Arabic. In Ethiopia, coffee is highly consumed locally than it is exported. In most part of the Horn of Africa mainly Ethiopia wild fruits are used as supplementary food and as marketable resources and are entirely for local markets (Fetien and Sara, 2008).

Medicinal plants:

Being rich in plant biodiversity and medical lore, the majority of the Horn of Africa in both highlands, arid and semiarid, and humid and sub-humid areas relay on traditional medicine for primary healthcare because they are cheaper, accessible etc. than modern medicine. The forests and woodlands provide as much as 75 to 90 percent of Ethiopia's rural population's requirements for traditional medicine (NBSAP, 2005). Most medicinal plants are collected mainly for domestic consumption. However, some medicinal plants are sold in practitioners' clinics such as *Eucalyptus globulus*, etc. (Dessalegn Desissa, 2001). In many indigenous communities such as Borana, Hamar and Konso, medicinal plants are not sold for money but through exchange of cattle. Transfer of medicinal indigenous knowledge among Shinasha and Gumuz is highly confidential.

Aromatic plants:

There are lots of aromatic plants in the Horn of Africa varying with different agroecological areas. There is high demandd everywhere. According to Fetien and Sara (2008) there were 44 different woody aromatic plants used by womenin Mekhoni and Alage, where the aromatic fumigation culture is well known that there were more unique plants. There are places in Ethiopia specialized in aromatic species and practices; for example, the half northern escarpments of the rift valley bordering Afar where the knowledge base is probable the mothers of Afar. It is the true culture of the Afar women and women facing Afar. The most common aromatic plants are used by women for beautification but vary from place to place according to the richness of the agro-ecology. However, the distribution and use of the aromatic plants are domesticated and planted at homestead areas of eastern Wollo households managed by women and they earn a lot of money from aromatic plants such as kufkuf and tisatis which are mixed.

Wild honey and Beewax:

The Horn of African countries especially Ethiopia's wide climatic and edaphic variability have endowed this country with diverse and unique flowering plants, thus making it highly suitable for sustaining a large number of bee colonies. Stingless honeybees called Trigona spp., which produce a special honey called Tazma. Beekeeping is one of the oldest ways of subsistence in Ethiopia (Deffar, 1988); probably no country has a longer tradition of beekeeping than Ethiopia (Hartmann, 2004). Later with the spread of Christianity in the country, the use of honey and beewax candles became part of the Orthodox Church religion (Greiling, 2001). Honey bee production belongs to all people wealth and categories and practiced by both genders. It belongs to wider agro-ecology and beehives can be modified based on the agro-ecological zones including adapting to the negative effect of climate change. Beekeeping is carried out in humid, mid-lands and drylands. However, many do not know or recognize its contribution as pollinators.

CHAPTER SIX

ECOLOGICAL AGRICULTURE BEGINS FROM THE SOIL

6.1: Soil health and fertility improvement

Soil health is the capacity of soil to function as a vital living system to sustain biological productivity, maintain environmental quality, and promote plant, animal, and human health while soil fertility is the ability of a soil to supply elements essential for plant growth without a toxic concentration (MOA and GIZ, 2020). Soil properties which can change rapidly in response to natural or anthropogenic actions are considered as good soil health indicators. Most of them generally have a slow response, as compared to the microbiological and biochemical properties because they change rapidly due to perturbation caused by different agricultural management paradigm (Amitava Rakshit et al., 2020).

6.1.1: Soil fertility and productivity enhancement practices

Traditionally, the Horn of Africa mainly Ethiopian farmers use a range of soil management practices for maintaining the fertility and health of their soil and produce more. Crop rotation with cereals followed by pulses are still practiced to a limited extent but the use of fallow has virtually disappeared; they also collect and apply animal dung.

6.1.2: Compost feeds the soil and enhances agricultural production

Compost contains many nutrients mainly NPK, which are useful for plant growth; improves the organic matter in the soil; helps the soil hold both water and air; and unlike chemical fertilizer, it also gives trace elements or micronutrients needed by plants. However, there exists a wide variation in the quality differences in compost products depending upon the inputs used and the composting media used. These days farmers are convinced that compost is not only improving agricultural yield but also overcome the challenge of climate change, means of escaping out of poverty and more. For example, farmer Ararsa Hamdi is a farmer married and has children, lives in the Adi Abo Mossa village, of Southern Tigray. In 1998, he was very poor without any plow oxen. By 2004, he had been able to buy two oxen, three sheep and one donkey. But later, after he uses compost, it supported him owning a pair of oxen (Hailu and Sue, 2012). This is because he planted his crops without any expense for chemical fertilizer. He also witnessed that comopost brough more synergy to the agriculture i.e. the nature of his soil was also improved become spongy and hold moisture due to application of compost. Therefore, compost improves production, productivity, food security and adapt to climate change.

Some of the types of composts practiced these days are listed below:

Bio-slurry enhanced compost

Bio-slurry, liquid fertilizer from biogas digester plants, is rich in plant nutrients and has excellent fertilizer qualities and has multiple benefits in agrculture as a sustainable alternative soil amendment. It is a good source of composting material as liquid animal manure and replaces water for composting. It can be used as valuable organic fertilizer by famers to improve crop yield, can be sprayed over crops against insect pest.

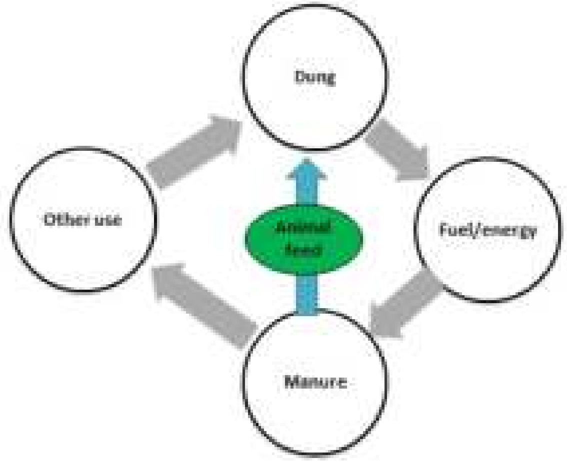

Figure 19: Multiple use of biogas

Liquid bioslurry is good for diversifying homestead garden especially vegetable and fruits because it is also good source of moisture. Thus, less water or moisture is required to produce vegetable in garden area. Evidences from the National Biogas Program of Ethiopia supported by HIVOS, SNV and the Ethiopian government show many families improved their livelihood due to the introduction of biogas.

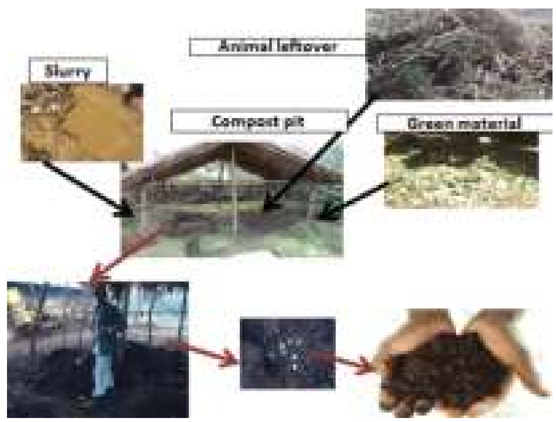

Figure 20: Bioslurry enhanced quality compost

The work of the late farmer Beyene Tadesse was outstanding one which was witnessed and presented here as a model example. He had shared his experiences and innovations in making and using bioslurry compost. The late Beyene and his wife Weizero Shallo Alemu live in Hitossa Wereda of West Arsi Zone in Oromiya Region. They lease farm land from neighboring farmers every year (Hailu et al., 2012). The dominant crop in the area is bread wheat followed by maize and then some pulses. The local community used to apply fertilizer every year but now they shifted to compost following the late Beyene Tadesse's experiences and innovation. His compost making process so that it is shortened, ready in 30 to 40 days[6], as compared to 4 to 6 months from the conventional composting prepared by other farmers. He lease any farm land from people without knowing its fertility level because not only he but also others knows that he will build the fertility of the soil after one year. That is why they want to give their land for him at cheap leasing prices in order to get back the farm already built by its residual effects (Hailu et al., 2012).

[6] His compost making is by mixing all composting inputs

Figure 21: Effect of bioslurry compost on crops, vegetables, spieces, etc

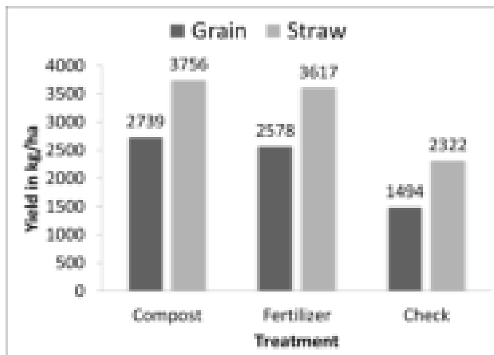

Figure 22: The effect of compost on wheat (2010) at moisture deficit area of Hintalo Wejerat (Tigray)

The effect of compost on the grain and straw yield of wheat grown 2010 in moisture stress area of Hintalo Wejerat, Tigray region is shown in Fig. 21. Its effect is amazingly high in moisture stress areas. It increased crop and biomass yields; improved soil fertility, soil health and soil structure (Hailu, 2010). The graph indicates that there is a significant yield increment that the application of either bioslurry compost or chemical fertilizer almost doubled the yield of grain and straw compared to the check, which is an indication of the soil very poor to grow crops without any input. But the yield was response from applying bioslurry compost to their fields was large in the moisture stress area of Hintalo Wejerat increased over 45% for grain and 38% for straw of compost (Hailu et al., 2012).

The photo below also indicate application of bioslurry compost also overcome the challenge of climate change; reduce the challenge of insect, pest and disease (see the following figure how bioslurry compost resisted wheat rust in Arsi area), etc (Hailu et al., 2012).

Figure 23: The effect of bioslurry compost on crop protection

Vermicomposting is one of the cheapest, easiest and fastest methods of recycling and production of high quality compost from agricultural residues and other wastes. These days it is becoming popular under farmers smallholder management. The vermi casts are rich in nutrients, growth promoting substances, beneficial soil micro flora and have properties of inhibiting pathogenic microbes (Gudeta et al., 2022). Decomposable organic wastes such as kitchen waste, farm residues and forest litters are commonly used. Cow dung and dried chopped crop residues are the key raw materials; mixtures of leguminous and non-leguminous crop residues enrich the quality of vermi-compost.

Figure 24: Vermi-worm (Eisenia fatida)

Figure 24 depicts a farmer, called Mr. Remedan Abdo, from Haramaya Watershed, East Hararghe Zone widely utilizing vermi-compost on various vegetable crops. As it stands now, he rarely utilizes chemical fertilizers as practical evidences exhibited highly increased biomass production, water holding capacity and improved aggregate stability of the soils.

Figure 25: Vermicompost production and application on to different vegetables

Model Farmers in West Shewa Zone are also widely involving in vermicomposting processes with their own innovative approach and the progress is highly promising. It has been observed that model farmers are preparing best quality vermi-compost using agricultural wastes and applying to different crops. They are convinced that application of vermi-compost to degraded/poor soils can quickly rehabilitate the soils and enhance crop productivities. The maize crop fields which are illustrated in Figure 25 below were planted in acid affected and degraded farmlands but showed excellent performance.

Figure 26: Farmers preparing their own vermicomposts and applying to maize field at Ilu Gelan District, West Shoa Zone

6.2. Complementing Organic and Inorganic Fertilizers

The highest production of grain and/or straw is not always by the application of chemical fertilizer or orgnic fertilizer alone. Evidences show that farmers had their own innovations where they combined organic resources and generally appreciable yields were obtained from these innovations. The highest grain tef production in Tahtai Maichew District was by combining compost and chemical fertilizer i.e. grain production 3.2t/ha of compost plus 10 percent of chemical fertilizer while straw yield was highest with 6.4t/ha plus 25 percent chemical fertilizer. Generally, grain, straw and total biomass yield are highest when the organic and chemical fertilizer are combined than compost or chemical fertilizer is applied alone (Table 3 or 4).

Table 4: Teff grain and straw yield (kg ha^{-1}) by treatment in Tahtai Maichew district

No.	**Treatment**	**Grain yield ($kgha^{-1}$)**	**Straw yield ($kgha^{-1}$)**	**Biomass yield ($kgha^{-1}$)**
1	Control	917	1,833	2,750
2	3.2t comp	1,000	1,500	2,500
3	3.2t comp + 10% MF	**(1) 1,125**	2,000	3,125
4	3.2t comp + 25% MF	1,000	**(2) 2,833**	**(2) 3,833**
5	3.2t comp + 50% MF	1,000	**(3) 2,500**	**(3) 3,500**
6	6.4t comp	1,000	2,000	3,000
7	6.4t comp + 10% MF	**(2) 1,083**	**(4) 2,417**	**(3) 3,500**
8	6.4t comp + 25% MF	917	**(1) 3,167**	**(1) 4,084**
9	6.4t comp + 50% MF	833	2,250	3,083
10	MF	833	2,167	3,000
	Average	**971**	**2,267**	**3,238**

Source: Tahtai Maichew District demo report, 2012
Key: MF – mineral fertilizer; comp - compost

Different research reports show that sole application of *Calliandra calotyrsus*, *Leucaena trichandra trichandra*, *Mucunapruriens*, *Crotalaria ochroleuca*, *Tithonia diversifolia* and cattle manure at 60 kg N ha^{-1} or combined application of the organic materials (30 kg N ha^{-1}) plus inorganic fertilizer (30 kg N ha^{-1}) gave significantly ($P < 0.05$) higher maize grain yields than the recommended rate of inorganic fertilizer (60 kg N ha^{-1}). These Integrated Soil Fertility Management (ISFM) treatments maintained maize yields at 4 to 6 t ha^{-1} (Mugwe et al, 2007). This indicates combining use of inputs is not only compromising both input applications rates but also agroecological efficiency and synergy of resources for a better production. Moreover, this is an indication of sovereignty that is widening options for farmers to choose and decide.

6.3. Green manure

The reality in the ground shows there is a practice of intercropping of legume crops with other crops to refresh the nutrient level of agricultural soils. Some of the practices are:

i. **Intercropping of haricot bean with maize**

Haricot bean is an important pulse crop in parts of Oromia, Amhara, Sidama, Wolayita and Gamo Gofa (Fig. 26) of Ethiopia. Haricot bean contributes greatly towards a balanced and healthy diet considered as 'a poor man's meat' because of its high protein content, which improves nutrition security where people's diet is dominated with maize, root and tuber crops (Walelign, 2015). Intercropping is largely practiced by farmers facing land scarcity such as Konso (Tesfaye, 2006). Some of the reasons that make intercropping attractive are:- increases total production through improved land use efficiency, improves yield stability, slows spread of pathogens and pests in the field and reduces fertilizer expenses. The crops that grow together under intercropping need to complement one another, as much as possible (Walelign, 2015).

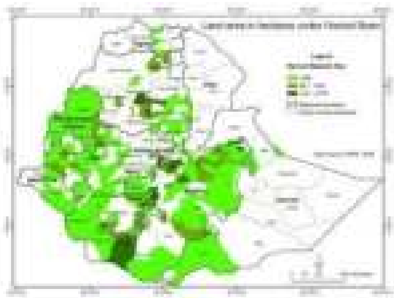

Figure 27: Areas under haricot maize-bean intercropping practice in Ethiopia (IFPRI, 2009)

Figure 28: Haricot maize-bean intercropping practice

ii. Effect of Vetch (*Delicos lablab*) on wheat yield

The effect of vetch as green manure (GM) applied alone and in combination with N fertilizer on wheat was studied for two years (2007-08) at two locations in Southern Ethiopia. According to the study by Wassie and Shiferaw (2009) GM applied alone and in combination with inorganic N fertilizers significantly increased grain yield of wheat by 63% and 97% over the control at Kokate and Hossan locations respectively (Table 5). Similarly, the combined applications of GM and 23 kgha^{-1} N increased the grained by 70% and 117% over the control at Kokate and Hossana respectively. These results showed that the N fertilizer rate can by decreased by up to half while getting high yield of wheat through integrated application of fertilizer with GM (Wassie and Shiferaw, 2009).

Figure 29: Vetch grown at Kokate, wolaita

Table 5: The effect of vetch (Delicos lablab) as Green Manure (GM) on Wheat at Kokate and Hossana, Southern Ethiopia

Treatment	Mean Grain Yield (kgha^{-1})	
	Kokate	**Hossana**
Control	2011c	1443b
GM + ON	3282ab	2857a
GM0 + 23N	2926b	2956a
GM + 23N	3417ab	3141a
GM0 +46N	3329ab	3392a
GM + 46N	3529a	2954a
lGM0 + 69N	3502a	3267a
GM + 69N	3630a	3130a
LSD (0.05)	**327**	**365**
CV (%)	**10.7**	**13.3**

Source: Wassie Haile and Shiferaw Boke (2009); **key**: GM – green manure;

iii. Alternately planting of lupin

At Awie zone parts of Banja, Ankesha and Machakel woredas of West Gojjam enhancement of soil fertility is practiced by planting of legume crop called 'Gebetoo or lupin' grown alone or intercropped on degraded and infertile farm land. Lupin keeps moisture and evergreen in the dry season when it is sown or planted and it improves the soil for two to four consecutive years. The residue could be used as mulch.

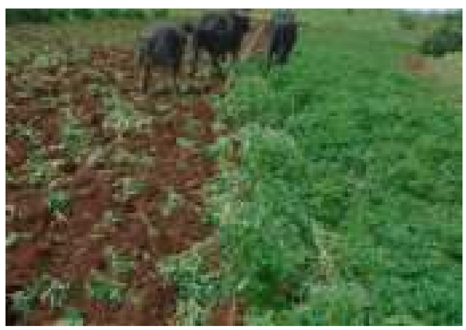

Figure 30: Gebeto (lupin) incorporated as green manure at West Gojjam

6.4. Liquid manure

Liquid manure is a fermented juice of leaves, fruits, stems or roots of plant materials prepared by chopping and soaking with liquid material (water, dung and urine) (Table 30). The plants or green materials used for the preparation of liquid fertilizer are of plants known by their soft and dark green leaves rich with high nutrient content mainly of nitrogen.

Figure 31 - Soft leaved green materials (A); chopping and grounding (B) and mixing the concentrated biofertilizer with water before use by Farmer Gebreyesus Tesfay (C)

Using liquid fertilizer has shown significant results under farmers' application. The best results observed are in vegetables (lettuce, beat-root, cabbage, green pepper, tomato, and pumpkin); fruit trees (banana, enset, papaya, guava and orange) and field crops (wheat, barley, maize, finger millet, sorghum and tef). The effectiveness and efficiency of liquid fertlizer is high when it is applied in row planting and targeted individual plants. The following evidences were observed from the users. These are: Farmer Gebreyesus applied liquid fertilizer to head cabbages and the result was not only bigger but also matured earlier than the cabbage grown with chemical fertilizer. He also applied on maize and it became healthy with strong stems and bigger cobs. It was resistance to pest and disease especially to termite as compared to maize crop grown with other input applications.

Figure 32 – Ato Gebreyesus's cabbage field (to the left of the line with chemical fertilizer while to the right of the line is by biofertilizer)

As observed above application of liquid fertilizer has indicated an immediate response in improving the performance of plants (vegetables, fruits and crops). The performances of the stems, leaves and fruits are impressive. The release level of their nutrient is very fast. Their production level has improved dramatically. As there is high demand of nutrients by crops in irrigation areas it could be one inlet in dissemination of this technology. It has a high potential in soil productivity improvement (Hailu *et al.*, 2015).

Figure 33 - The performance of garlic and onion by biofertilizer application (Tahtay Maychew area)

6.5. Integrated soil fertility management (ISFM)

ISFM is a set of soil fertility management practices that necessarily include the use of organic and inorganic inputs, improved germplasm and their managements (Chivenge et al., 2009) with knowledge on how to adapt these practices to local conditions aiming at optimizing agronomic use efficiency of applied nutrients and improving crop productivity" (Faihurst, 2012). It is one of the best soil fertility and soil health improving technology proven to be effective in sub-Saharan Africa (SSA) landscape. ISFM practices have been proved to result in superior yield of crops than that produced with single application because neither organic nor inorganic fertilizer is able to supply the full ranges of nutrients required by crops in sufficient quantities.

The following are reports from BMZ Special Initiative 'One World – No Hunger' (SEWOH) funded project, which is called as ISFM+, aimed to improve soil fertility and productivity in four regions of Ethiopia under small-scale farmer management (ISFM+ project report, 2018).

Figure 34: Wheat demonstration ISFM (left) and control (right)

ISFM Quick Win technologies increased grain yield of all the crops compared to the farmer practices. On average, grain yields were increased by 50% and residue yields by 32% in non-acidic areas while in acidic areas, the use of 'Quick Wins + Lime' technologies increased grain yields by 80% and residue yields by 58% (Fig. 34). The average grain yield advantage of 'Quick Wins + Lime' ranged from 70% for teff to 86% for maize. For wheat and faba bean, yield increments over the conventional farmer practices were 80% and 78% respectively. Highest average grain yield increments were observed in Oromia in wheat (127%) and faba bean (115%). Individual Quick Win technologies have a significant effect on the yield ($p < 0.05$).

Compared with the results obtained with ISFM ‘Quick Wins’ demonstrations presented above, the ‘Quick Wins + Lime’ treatment resulted in considerably higher yield increments. This highlights the strongly negative effect of soil acidity on crop productivity in the highlands.

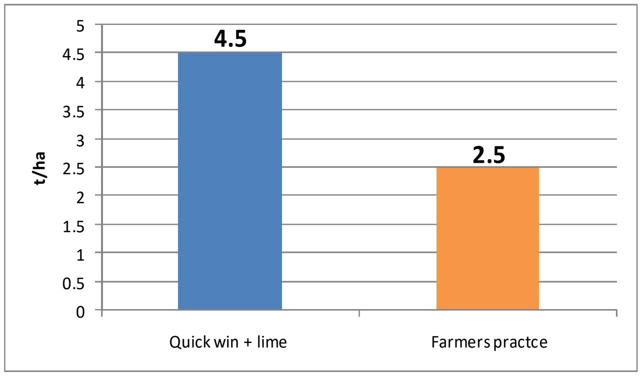

Figure 35: Effects of ISFM technologies on grain yields, across regions and crops, n=208, statistical significance at $p < 0.001$. Adapted from GIZ (unpublished) with permission

ISFM technologies increased crop productivity substantially. Compared to farmer practice, grain and crop residue increased by 70% and 64% respectively, with the value of total output increasing by 65 %. Gross margins per hactare increased for all crops, the greatest increase being for faba beans (128%), while teff showed the highest gross margin in all regions.

Although the total input cost increased by 28%, productivity increases in terms of gross margin per hactare increased by 85%, returns to labor by 58% and benefit cost ratio (outputs/inputs) by 29%. On average, gross margins per hectare increased from ETB 19,397 with farmer practice to ETB 35,976 using ISFM, with labor returns per day increasing from ETB 203 to ETB 321 per day.

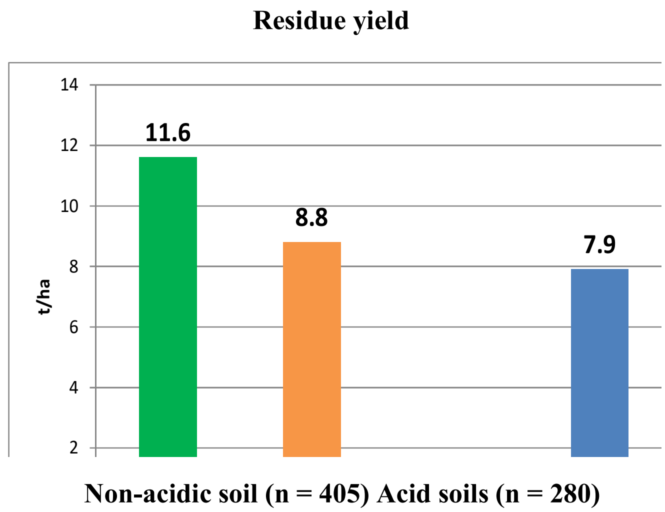

Figure 36: Effects of ISFM technologies on grain yields cross regions and crops, statistical significance at $p < .001$. Adapted from GIZ (unpublished) with permission

The yield data shows that Quick Win technologies increase yield significantly on non-acidic soil and even more so on acidic soil. Therefore, it is a promising approach for smallholder farmers in the degraded highlands of Ethiopia to increase soil fertility and productivity in the long term. The cost benefit analysis shows that if farmers adopt ISFM technologies, it will increase their crop productivity and benefits them economically. The use of biofertilizer (rhizobia) in faba bean can be achieved with relatively low investment.

6.6. Ecological soil acidity treatment

About 46% of arable lands of Ethiopian highlands are affected by soil acidity (Fig. 36). It is mainly due to leaching of the basic cations out of the soil which leads to Aluminium and Manganase toxicities to plants andmicrobial organisms. Microbial activitities drops off in acidic conditions which can lower nitrogen concentrations, reducing nitrogen fixation and nitrogen mineralization. In strongly acidic soils organic matter decomposition by soil micro-organisms decreased or stopped resulting in decreased nutrient release and supply to plants. Roots of crops growing in such strong acidic soils, suffer from direct toxicities of H^+ and Al^{3+} ions leading to decreased uptake of water and nutrient. Moreover, availability of plant nutrients especially phosphorus is low to crops or plants growing acidic soils. Thus, crops growing in such soils are confronted with several challenges severely decreasing their growths and yield. Evidences show incidences of 100% crop yield losses due to strong soil acidity in many areas of the country (Desta, 1988; Wassie and Tekalign, 2013). The negative impact of soil acidity on wheat production alone is estimated to cost the country over 9 billion Ethiopian birr per year (MoA/EIAR, 2014).

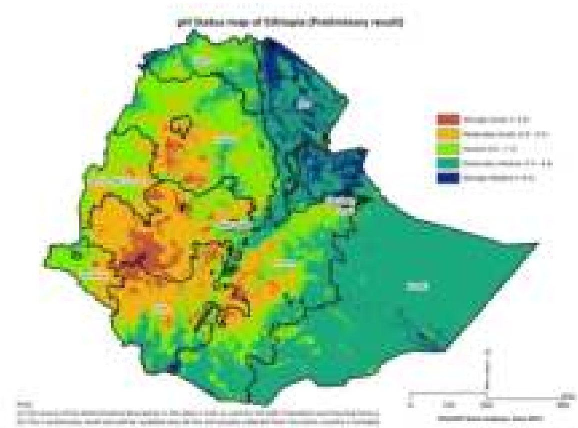

Figure 37: Geographical distribution of acid soil in Ethiopia (ATA, 2017)

Figure 38: Abandoned lands around Assosa

The following are some of the different ways of reclaiming soil acidity agroecologically:

6.6.1. Lime application

Lime application neutralizes soil acidity. Research carried out by national and international research and development organizations consistently shows that soil acidity can be effectively reduced through the application of relatively small quantities of agricultural lime (2 to 4 tha^{-1}). The effects of lime on crop yields in highly acidic areas are dramatic, especially if combined with integrated soil fertility improvement techniques such as use of acid soil tolerance crop varieties, blended fertilizer, organic soil amendments and line seeding (row planting). Yield increases up to 300% have been reported (ATA, 2015). Reports show that productivity gains from applying agricultural lime range from 50% to over 100% in wheat, barley, tef, soybean and maize (MoA/EIAR, 2014). Similarly, results from 280 large-scale field demonstrations in 12 acidic woredas in Amhara and Oromia indicate average grain yield increases of 80% where lime is part of the ISFM practices which combine improved seed, blended fertilizer and compost (GIZ, 2017).

6.6.2. Planting deep rooted crops (farmer's practice)

Normally farmers in Ethiopia do not sit and wait looking for someone come and solve their problems. Instead, they innovate and/or try their own ways. There are list of options practiced by farmers. Farmers were trying to plant permanent or deep rooted trees after their soil is being exhausted.

Although it is not advised to plant trees like eucalyptus trees around farms and water sources because it drains water farmers are growing it on their farm land. It is common practice in most part of areas of East and West Gojjam, large part of Oromiya and upper Rift Valley areas of South Nations, Nationalities and People's Regional State to plant eucalyptus trees on strangly acidic soils.

Figure 39: Abadnoned land by strong acidic farms planted with eucalyptus trees

The case in point is the experience of Ato Ereamo Tuptupo, a farmer in East Lesho kebele of Kacha bira woreda in Kembata Tembaro Zone, Southern Ethiopia. His about half a hectare is seen covered with eucalyptus trees because his land is affected by soil acidity and the yield has been decreasing. Having no choice, he said, he decided to grow eucalyptus on his farm because it is a normal practice in his area.

Benishangul Gumuz is known for its dense bamboo forest but these days it is observed that big areas are cleared due to the resettlement program during the Derge regime and exploitative and unplanned investments. They cleared the forest, cultivate for some time and then they could not reverse the soil situation. Then now it is easy to see abandoned land while others are trying to cover their farms with eucalyptus, mango and bamboo plantations (Figure 39).

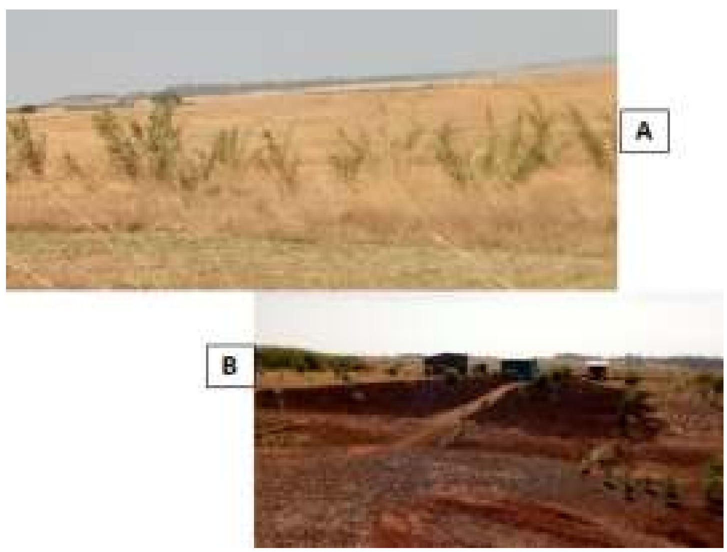

Figure 40: Replanting of bamboo frees (A) and mango trees (B) in deforested and abandoned areas of Assosa wereda of Benishagul Gumuz Region

Another practice is planting of *Acacia decurrens*. Farmers in West Gojjam are challenged by highly deteriorated soil and strong soil acidity. According to the report of BOMWAN (2015/2016) at least 25-33% of the smallholders' farm land is invaded by eucalyptus and decurrens trees in the districts of West Gojjam zone and East Gojjam zone. Decurrens is a fast-growing tree. They plant it in the whole field mixed with crops especially with teff in the first year and continue untils its shade protect crops to grow. They harvest after the acacia is matured for firewood and charcoal and then shift to crop cultivation. At this stage the soil gets well rehabilitated.

Figure 41: Tef field intercropped with acacia decurrens (West Gojjam)

Therefore, farmers are improving their production and productivity of their land through planting tree increasing biomass in the plough layer. It also improves the pH of the soil. Assessment in Benishangul Gumuz shows fields surrounded by permanent vegetation have neutral soil pH while around degraded landscape have lower pH that is acidic soil.

6.7. Ecological Urban Agriculture

All cities in Ethiopia are endowed with high urban waste due to the one direction movement of agricultural products from rural to urban areas. This is a process of removing soil nutrients from their origin in the rural to urban areas. Then they become urban wastes. However, if they are properly managed and used they are recyclable organic materials that can be used to enhance soil fertility and increase agricultural production. Otherwise they are sources of urban environmental problems.

There are individuals and few municipalities in Ethiopia trying to properly manage and use urban waste recycle into compost, or biogas. These are:

- **Green Renewable Energy and Environment:** It is a cooperative in Hawassa was established in 2016. They prepare compost in the landfill area using urban solid waste. They prepare up to 500 quintals of compost per month the whole year round. The main market for compost is city urban greenery development. Based on the agreement made between the cooperative and city administration, the green development association bought compost on quarter basis. There are similar efforts at Bishoftu town. All urban wastes from the city is collected, delivered to a collection composted in shaded houses and then used for the city greenery and beautification. As it is well managed process for sure it will sustain for a very long time.

Figure 42: Compost prepared and ready for sell in Hawassa

- **Selam Horticulture Growers Association:** This assosication is found in Adi-Haqi area of Mekele city. They grow horticultural crop alongside river, since 2004. They produce different types of fruits and vegetables. These are: Swiss chard, lettuce, green pepper, avocado, banana, papaya, orange, guava, lemon, apple, coffee, maize, bamboo, and others tree and medicinal plants on 0.75 ha of land using compost as soil fertilizer and river and water-well for irrigation.

Figure 43: Some photos of their urban agriculture

- **Individual efforts:** There are unlimited numbers of successful urban agriculture efforts by individuals in different parts of the country indicated below.

Figure 44: (A) - mushroom inside and vegetables outside (Bole sub-city); (B) - poultry farm inside and vegetable outisde (Yeka sub-city)

Figure 45: Examples of narrow and wide spaced urban agriculture respectively

Although composting of urban waste reduce solid waste, municipal expenditure of waste management, reduce carbon emission, prepare input for greenery and urban agriculture development such activities do not sustain due to lack of market connection in selling their compost products. The horticultural activities in urban areas have played great role in their livelihood improvement. They are good source of income and family consumption. Apart from economic benefits, the horticulture production and growing of different trees and plants improved biodiversity and micro-climate as well as greening and land stabilization. However, this form of economic activity is lacking policy support such as recognition, provision of inputs and technical support to improve their economic benefits.

6.8. Kitchen Gardening

A kitchen garden is a type of garden that recycles organic biomass. It is usually used by resource poor farmers and they render good results in enabling the families grow enough vegetables to eat and sell. It has a central 'basket' where compostable waste is placed and water is poured. They are especially useful in areas where good soil is scarce. Then their land becomes productive to feed themselves and providing surplus that they can sell to generate and diversify their income, save money, and survive. This gardening approach gives good opportunity for urban families and smallholder farmers to find their own production system with simple technical assistance.

This has shown effective results in areas where land is scarce like Wolaitta resulting in low production and productivity leading to vicous circle of food insecurity. However, since the introduction of ecological agriculture based on the Developing Farmers towards Food and Income Security project by Send A Cow, which ran from July 2012 to June 2015, small farmers have been helped to recognize the resources they already have: land, livestock if any, and their own capacities.

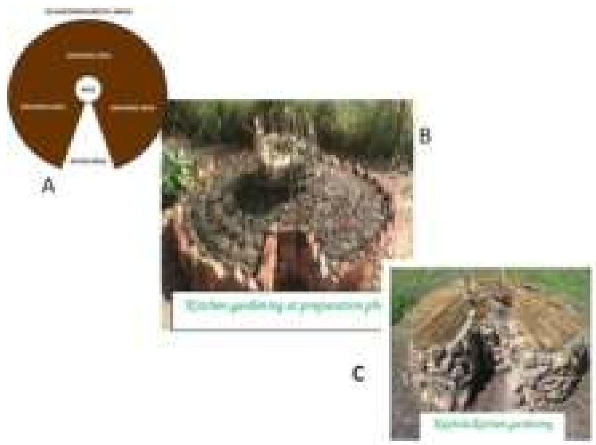

Figure 46: How to design and build kitchen garden

Based on these small capacity building supports, farmers began making use of their small plots in front of their houses, and promoting kitchen gardening and growing of vegetables. They discovered that they can increase their family income and nutrition through vegetable gardening alone. Within just one year of a three-year project period, the percentage of people rated as severely food insecure dropped by 70 to 90 percent. Within three years, their incomes rise four-fold. People are also eating better: within two years, their diets are diverse even in the hungry months. Within less than one year, people's food security is rising significantly and the number of 'hungry months' between harvests is decreasing. Keyhole gardens are also a great way of introducing children (and adults), to sustainable principles such as composting, efficient water and resource use and food security.

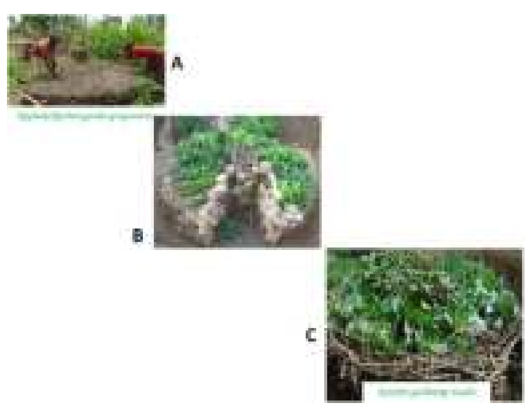

Figure 47: Effect of Kitchen garden

CHAPTER SEVEN

AGROECOLOGY ENCOURAGES NATURAL CROP/ PLANT PROTECTION

Insect pests and diseases are amongst the main challenges of Ethiopian agrculture. The overall yield losses from pests range from 30-70% (Aberra, 2003). The estimated figure includes losses caused by plant pathogens, insect pests, and weeds. Several diseases caused by fungi, bacteria, viruses and nematodes have been known to cause serious yield reductions in several crops. Rodents and other vertebrate pests have also been identified as causes of serious crop yield losses in the country. Therefore, effective and sound plant protection mechanisms make vital contribution to sustaining agricultural production. The agricultural extension service of the country is providing different control measures but their practical utilization is observed as risky as they are unsafe practices. Contary to this, there are environmentally friendly, economically feasible and socially acceptable control measures being practiced here and there.

7.1 No to GMO through Ecological cotton production

7.1.1. Food sprays for ecological cotton production

Cotton is grown globally in good quantity by smallholder and commercial farmers. It is one of the highest consumers of synthetic pesticides because it is attacked by a wide range of pests such as bollworms (Helicoverpa spp.) and sucking pests (MoA, 2013). The negative impacts of synthetic pesticides on human and environmental health underlie growing concerns over the unsustainability of long-term reliance on these chemicals worsening due to limited knowledge of cotton farmers on the effects of the use of pesticides and lack of appropriate and easily accessible alternatives (Amera and Abate, 2008; Williamson, 2011). There have been some positive results in the development of alternative pest management options for cotton production (Mensah et al., 2013) such as the use of beneficial insects. This has attracted the attention of farmers and government departments. The use of food spray technique, made from maize flour and need seed, to manage insect pests in cotton farms as ecological means is benefiting farmers and the environment. This technique helps to maintain the survival of both pest and beneficial insects in balance; protecting natural ecosystem is taken into account; the risks in human and animal health that occur due to the use of chemical pesticided are avoided ; certified organic cotton and seed production and marketing started (Figure 48) (Hailu and Yohannes, 2017).

Figure 48: Certified Organic cotton from Shelle Mela, SNNP

7.1.2. Molasses trap for controlling cotton boll worms

Mostly small scale farmers are not well aware of improved control mechanisms and economic damage occurs both in yield and quality. Hence, locally available alternatives like molasses are indispensable to offset the damage. Molasses (liquid by-product of sugar factories) trap usually controls moths, effectively reduces likelihood of ***hatching*** to bollworms, and protects crops before any attack (Figure 49).

Figure 49: Molasses trap preparation and setup procedure

It can decrease cost of controlling bollworm with the use of molasses trap (Abdut et al., 2008). It does not harm soil, surface and ground water or any other natural resources; it has minimal effect on beneficial insects. The use of molasses trap has good potential to minimize sprays and health hazards of chemicals on farmers and animals. It is easier to set up, cheaper, effective, and environmentally friendly to control cotton bollworms. It can also be used for controlling similar insect pests on maize and sorghum (stem-borer). Small scale cotton farmers and large scale commercial farms alike can use this control method as integral part of IPM tool to satisfy the demand of sustainable cotton by textile mills to compete in the international market.

7.1.3. Ecological control of cotton pests through intercropping

Mai-Tsebri is a district in western Tigray Region bordering Tekeze River. This district has 11 known cotton producer kebeles. They produce, collect and sell good amount of cotton. Farmers in these villages produce cotton in ecologically friendly approach through intercropping it with maize and sorghum. They plant sorghum or maize sparsely in order to give space for interplant the cotton seed after first or second weeding time. As a culture, farmers do not apply chemical fertilizer on their fields. Always all crops are at good stand whenever they are intercropped together. Generally, all approaches witnessed quality yield and higher income from ecological and/or organic production of cotton. This production system enhances safety for the families in the ecosystem (Wereda Report, 2010; Hailu *et al.*, 2015).

7.2. Farmer innovation on crop/ plant protection

7.2.1. Managing Fall Army Worm through plant based Integrated Pest Management

Farmer Gebreyesus Tesfay and his wife Miss Saba Amare of Tahtai Maichew around Axum managed fall army worm ecologically using plant made solution. The plant solution (plant juice) was made from bitter plants, hot pepper etc. mixed with goat urine. They wanted to compare the effectiveness of their produce against pesticide. Gebreyesus sprayed the pesticide for controlling the fall army worm infestation. He also sprayed the plant juice on his maize plant when it was half a meter before any type of pest or insect visit the plant; again he sprayed the maize the plant juice after two weeks; he sprayed after two weeks for the third time. Finally, when all his neighbors' fields were affected by the fall army worm, however, his maize field was free including the pesticide applied maize field.

According to him, as compared with the modern pesticides, it is low cost, no harm for the crops and vegetables and promotes plant vigour. After they see the effect many people are asking him for the solution (plant juice). Then, he started selling the plant tea as income and sells it 300 birr per liter.

7.2.2. Hyena refusal for plant protection

Animal raid at night is one of the challenges of crop management by smallholder farmers. Even if farmers fence their crops, camel eats them across the fence because camel has long necks that can reach the plants inside across the fence. Therefore, one farmer in Wollo use hyena refusal to protect his fruit plant mainly chat and fruit plants. He collects hyena refusal then mix with water first. The liquid part is diluted with water after some days. Whenever he sprays the liquid solution on the plant neither camel nor any other animal eats their plant. It serves as repellent for all types of animals (Figure 50).

Figure 50: Container for mixing hyena refusal with water (upper left); spraying hyena refusal as a pest control option (bottom right)

7.2.3. Nonchemical insect control techniques

Small-scale farmers are less aware of the proper utilization and handling of agrochemicals. However, there are farmers practicing agro-ecologically suitable pest management techniques which are of their own innovations to offset the damage. Some of such outstanding pest management innovations are briefly presented as follows:

Ato Abera Ababi of Werebabu Wereda, South Wollo Zone in Ethiopia, has a long history of practicing an integrated pest management. His insect baiting technique attracts different types of insects. Many insects attracted to various baits, which can be applied to the ground, on trees, or elsewhere, and insects can be attracted and collected directly from them. Alternatively, certain types of traps can be baited with specific baits and the insects collected from the trap container. The substrates he used were mainly fresh gut fill by putting out some type of insect trap + blood + small amount of odorless insecticide/pesticide. It was hung on trees and a lot of various insects were attracted soon after application (Figure 51). This type of insect trapping/bait is a full diet for insects.

Figure 51: Abera Ababi demonstrating his innovation to farmers' of Tahtay Maichew, Axum area

Ato Abera's innovation is best among the available literatures to be used by farmers as effective onces. Benefits of this technology are: it is eco-friendly, no environmental and health impact, accessible and available technology, cheap, easy to apply and no need of special skill and effective sustainable locally tested practices, etc.

The science of agro-ecology explicitly recognizes the value of bottom-up participatory research and knowledge and promotes: (i) bridging formal and informal innovation processes; (ii) combining local expertise, with scientific knowledge; (iii) acknowledging respecting farmers as owners of knowledge and co-researchers and innovators. A demonstration was carried out in Tahtay Machew *Woreda* at *weyzero* Medhn's Guava farm by Ato Abera. Researchers from University were observing during the demonstration time and acknowledging Ato Abera's innovation.

Miss Mebrat Tesfay: A similar principle was made by Weyzero Mebrat Tesfay from Asgede Tsimbila District north western Tigray Ethiopia. She made a hole on the one side of a plastic bottle and she put a mixture of honey, water and *ghesho* (*Rhamnus prenoides* L.) and hung up it in her mango fruit trees. After a while, she found all the hung up bottles were filled with different insects. After observing the success she started multiplying and applying it to other insect infected fruit trees.

The reason why insects are attracted to the plastic bottles (Figure 52) is that the honey has carbohydrates and sugar contents and the water allow them to swim in. Later on, the insects trapped and were dead due to starvation and lack of food and air. Honey is a full diet baiting for the insects especially female insect need full diet before egg lying and attracted into the bottle which contains baits. Now her fruits are free of insect pests.

Figure 48: Insect baits prepared & used by Weyzero Mebrat (Photo by Kahsay Tadesse)

7.3. Striga and Stem-borer management

Stemborer and striga weed are the major problems of maize and sorghum in Africa. Maize yield losses due to stemborer are estimated to be 20-40 % while striga weed infestation causes 30-100% loss in maize yield (Figure 53). Spraying for stemborer control with pesticides is not only expensive and harmful to the environment but also ineffective. Weeding for striga control is both time-consuming and labour-intensive. The following management techniques have shown good results. These are:

Figure 49: Sorghum crops infested by striga weed in Humera, Tigrai (photo by Haileselassie Ghebremariam)

7.3.1. Push Pull Technology

The push-pull cropping strategy is described as a habitat management approach that controls *Striga, orobanche spp.* and stemborers and currently being practiced by over 30,000 smallholder farmers in eastern Africa (Zeyaur Khan et al., 2011). *Desmodium spp.* produces repellent odour to stemborer moths while Napier grass produces attractant volatiles. Push Pull Technology is ecological way, which involves trapping stemborers on highly attractant trap plants (the Napier grass) as a pull and driving them away from the maize crop using repellent intercrops (the desmodium) as a push. The desmodum plant repels stemborers and inhibits striga (Figure 54). These plants also provide high quality feed for livestock, thereby increasing their productivity in terms of meat and milk.

Figure 50: Push Pull Technology

Furthermore, the use of desmodium is widened through farmers' innovative capacities. For example,

- By 2012 Gebreyohannes lives in Mai Tsa'eda village of the Tahtay Maychew wereda planted maize on one of his pieces of lands, inter-planted with desmodium; the second pieces of land was covered by maize alone while the third piece of land was covered with finger millet and intercropped with sorghum. That year, there appeared to be no single striga and stem-borer was observed in the field of maize inter-planted with desmodium and bordered by Napier (elephant) grass. However, both striga and stem-borer were observed in both plots planted with maize and sorghum without desmodium inter-planted into the crops (Hailu *et al.*, 2015). In the following year (2013) the plot in which desmodium was established was planted again with maize and intercropped with garlic, tomato and green paper. All crops were good and healthy because they were less infested by stemborer and striga.
- W/ro (Miss) Ayal Abera lives in Passo Mile village of the Tehuledere wereda of South Wollo Zone. She was the first person to try the Push Pull Technology around her homestead farm. Her area was experienced with striga infestation for many years. It is also very widely spread around here village and farmers use striga as animal feed especially for cattle and camel. She was the first to try Push Pull Technology around here homestead and she found that her maize crop to be strong and healthy with Push Pull Technology as compared to none practicing neighbors. She got maize grain yield estimated to above 9tha^{-1} (Hailu *et al.*, 2015a).

Farmer Research Groups in Tselemti wereda

Maize is the most important staple food crop in Tselemti areas of Tigrai Region with high stem-borer and striga problems. Mai Tsebri Agriculture Research Center has accomplished a joint experimentation of Push Pull Technology by Farmer Research Group (FRG) approach through JICA support. It was done by organizing farmers into two groups interested in undertaking the activities. They planted the desmodium, elephant grass and maize at the same time.

The result of the Farmer Research Group (FRG) showed:

- The average stem-borer infested maize plants were found 11.5 in the control plot while only 5 infested maize plants in the plot treated by desmodium and elephant grass.
- There were 2.5 stem-borer infested cobs at 75% ear filling stage in the plots treated with desmodium and elephant grass while 5 at the control plot.
- The grain yield, biomass yield and harvest index were 6.84 tha^{-1}, 2.1060 tha^{-1} and 32.51 for the plots treated with desmodium respectively as compared to 5.360 tha^{-1}, 1.83 tha^{-1} and 28.98 with the control plots respectively.

7.3.2. Desdmodium as insect and pest trap in fruit orchard

Poor soil fertility, striga infestation, and occurrences of pest and diseases were the main challenge of Miss Haregu's fruit orchard. Later, she was using *desmodium* as animal feed and source of desmodium seed. She has witnessed that in addition to feeding her dairy cows striga weed was eliminated from her orchard field due to *desmodium*. In her area, many people have abandoned planting tomato because of the Striga problem. However, currently tomato is coming back because it is improved due to the introduction of desmodium. Moreover, ants disappeared in her fruit orchard due to desmodium because it has a sticky substance and it catches them before they climb to the fruit trees. In addition, root exudates of *Desmodium spp.* contain so many compounds, which stimulate germination of striga seeds and others dramatically inhibit its subsequent development, including radicle growth leading to suicidal germination ultimately resulting depletion of *striga* seed bank in the soil.

7.3.3. Controlling orobanche weed

Orobanche (Figure 55) is a parasitic weed in many parts of the highlands of Ethiopia. It suppresses the growth of vegetables cabbage, tomato, carrot, potato, fababean, etc. Gebreyesus Tesfay has tried and successfully controlled by planting desmodium plant. He prepared and planted two plots of tomato with desmodium and without desmodium plant. Orobanche parasite weed come out in the field without desmodium while plot with desmodium was free of orobanche. Another practice was planting of faba bean with and without desmodium. Faba bean with desmodium was free of orobanche unlike the plots without, which was highly infested (Hailu, et al., 2015a).

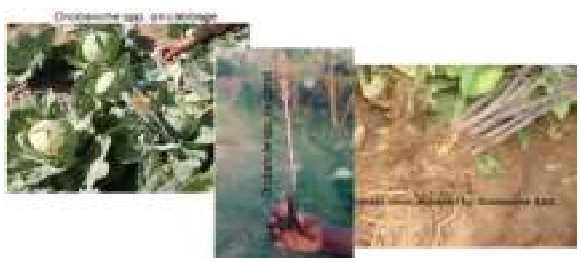

Figure 51: Parasitic weeds of *orobanche* infested different vegetable crops

7.3.4. Flood irrigation as ecological means of managing striga

The Rift Valley escarpment of the northern Ethiopian highlands facing Afar is moisture deficit area. The flood from the highlands is the main moisture supplement and sediment for crops in the area. Striga affects most of the sorghum areas of the lowlands from Shewa Robit to Moheni area of Tigray in Ethiopia. The local people believe that striga is not a problem if farmlands are fertile. It is observed that if farms are built up by silt soil from the highlands they are tolerant to striga weed. Therefore, the local people construct canals to divert the flow of flooding from the highlands. Farmers witnessed that it is not only sorghum stand and yields perform well but also they do not apply chemical fertilizer to the fields in the flooded farms (Figure 56).

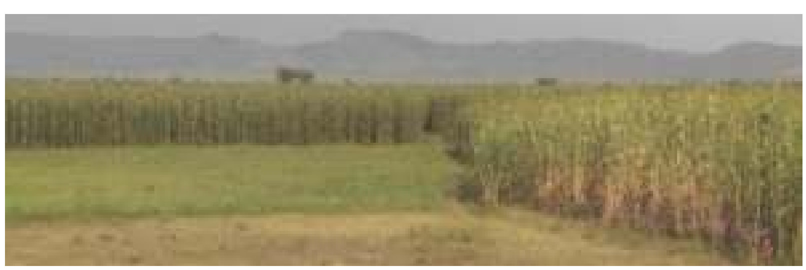

Figure 52: Sorghum field flooded (left) and not flooded (right) at Mehoni, Southern Tigray

CHAPTER EIGHT

AGRO-ECOLOGY BUILDS RESILIENCE CAPACITY TO CLIMATE CHANGE

8.1. Flood irrigation management

Flood or spate irrigation is a type of irrigation system whereby flood water travelling through normally dry wadis is conveyed to irrigable fields. It is characterized by flood flow for only a few hours. Spate irrigation has existed for many centuries as a major source of livelihood of mainly for economically disadvantaged communities in arid and semi-arid regions (Salem and Ibrahim, 2011). It largely operates under water scarcity conditions prevailing in arid and semi-arid regions in which inhabitants of these regions rely on flood water that is unpredictable in its occurrence, duration and volume. The study in drier area of Yemen by Salem and Ibrahim (2011) shows floodwater is considered to be one of the most important sources of irrigation in the area, and accounts for the irrigation of 70% of total agricultural lands in Yemen's southern and eastern governorates. Consequently, flood irrigation practice requires appropriate field water management and soil moisture conservation measures necessary to improve the possibility that a large portion of diverted flood water is retained within the root zone depth of the soil profile and made accessible for crop growth.

Sometimes these areas are sources of risk and disaster unless flood irrigation is used cautiously. It also includes river valleys in and beyond Ethiopia that is identified as river banks and lakes covered by seasonal water and then recede in the late season. The main good practices of spate irrigation in Ethiopia are: 1. Koneba-Bada around Dallol in the floor of the Great Rift Valley; 2. Raya Valley of northern Ethiopia; 3. Konso area in Southern Ethiopia; 4. Koneba traditional erken – Water-Spreading wier.

- Koneba and Bada areas are found around Dallol depression that is in the heart of the northern Rift Valley (Figure 57). They are dependent on the floods flowing down from the surrounding highlands of Eastern Tigray (Irob, Sa'esie Tsa'eda Imba and Atsbi Wenberta) and South Eastern Eritrea. This is because all the rivers from these escarpments between the highalnds and the Rift Valley flow towards the lowlands.

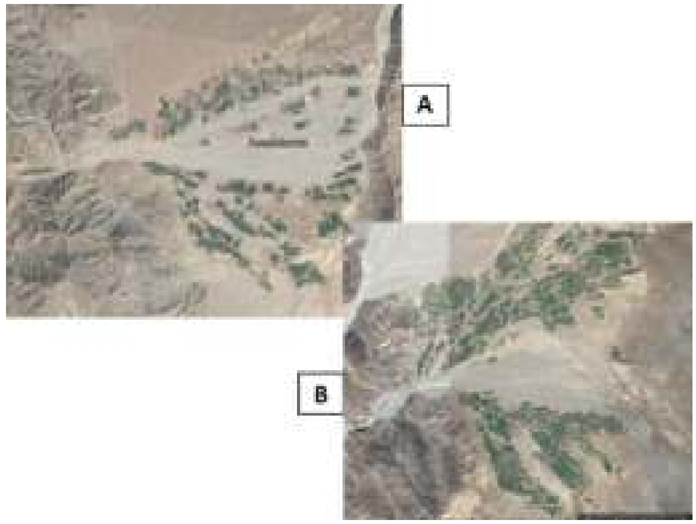

Figure 53: Spate irrigation in Koneba (A) and Bada (B) border between Eritrea and Ethiopia (adopted from google map)

- This part covers part of the Raya lowland lies between Enda Mehoni and Kobo areas (Figure 58). This part of Ethiopia is known for its moisture deficit for seasonal crops. Normally, without flood water there is no enough rainfall available; the flood from the highlands is the main supplement moisture and sediment for their crops. Farmers of the area overcome the challenge of moisture stress and soil fertility problem through flood from the nearby highlands enriched by organic matter and improves crop yield without incurring cost. When necessary farmers apply manure and compost otherwise chemical fertilizer aggravates wilting of their crops.

  All beneficiary farmers in these areas are organized as water user associations. They elect a socially trusted and accepted leader called Abogereb (the father of water or river). They expect from him that he administers or arbitrate them wisely and equally. He also manages not only about who should get water but also who should get sediment. Through his leadership they plan together on the construction or maintenance work of the canals, watering calendar, arrange or identify all crops which crops need to be watered before or after planting etc. According to the respondent farmers (Ato Molla Tefera, Baraki Meresa and Ato Teka), sedimentation increases soil depth and fertility and then obtained high crop yield. Farmers witnessed that through this technique striga is reduced.

Figure 54: Flood controlling trenches by farmers around Mehoni (South Tigray)

- Communities in Konso frequently suffer from drought. They live in the lowlands are dependent on diverting flood water. Konso people have been adapting the water scarcity and harsh environment through soil and water conservation activities in the highlands but in the lowlands they have developed amazing flood-harvesting structures in the seasonal riverbanks (Figure 59). Flood harvesting in Konso is all year round task. A drop of rain has great meaning in that moisture-stressed land. Whenever there is rainfall, every able member of the family runs to his field any time of a day or night. Everyone opens his canals by monitoring the field capacity, to protect loss of soil. This practice is common in the *Buso, Aba Roba* and *Nalia Segen* areas within Konso.

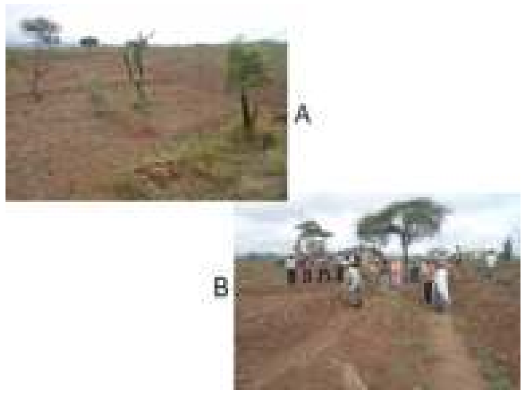

Figure 55: Water harvesting structures within plots at the Segen Irrigation project (A) and Arba Minch Diocese EECMY-DASCC irrigation project head Mr Galunde showing the diversion (B)

- Their hard working culture has helped for the success of the project. Farmers managed to have integrated farm cultivation with papaya, banana and mango. Moringa and onion apart from maize are largely produced crops in the area twice a year, through a community participatory development scheme. Ato Adene Korche is a model farmer and beneficiary of the project. He had lived with poverty for a long period of time due to food insecurity resulted from the drought hitting the area repeatedly and even went on resettlement. Yet, being part of the project returning from the resettlement program, benefited enormously by planting maize, banana, papaya, mango and onion harvesting up to 4.0 tha^{-1} in good seasons. Ato Adene built two improved houses, owned a motor bicycle, a pump and installed a grinding mill (Hailu and Yohannes, 2015) after involved in the EECMY DASSC irrigation project (Figure 60).

Figure 56: Ato Adane sharing his successful experience for visitors

- Koneba traditional erken looks like the Water-Spreading wier but built by about 50-60cm raised earth. People in Koneba area build canals to introduce flush-flood water into their fenced plot of land. Mostly, they grow grass and some times they plant their land with maize. Families who practice this structure could get enough animal feed even in 2-3 floods. There are local experts who build this for others by oxen driven heavy metal tools.

8.2. Adapting to climate change

The negative effects of climate change are manifested locally and globally. The risks on agricultural efficiency under smallholder farmers are very high as they depend solely on rainfall for their crop production. Rain water is the most critical resource as most farmers do not have access to alternative sources of water for irrigation. Therefore, the chance of crop failure is very high. When the rainy season comes late, the moisture shortagebecome more serious, and farmers have to shift from long growing season crops that is 3 to 5 months such as sorghum or finger millet to those that can mature in 2 months or less time such as teff. This shift from one seed into another seeds may incure cost for farmers, and farmers become more likely to have to sell their assets or to get into debt. There are some techniques practiced these days.

8.2.1. The System of Crop Intensification (SCI)

The System of Crop Intensification (SCI) also called planting in space developed by Institute for Sustainable Development (ISD) is a new field management (agronomic) technique that is now being adapted for a wide range of crops from the more widely known System of Rice Intensification (SRI[7]) to sorghum, finger millet and teff. SCI has been tried by ISD with communities in Tigray and Wollo since 2003. SCI comprises either direct seed sowing or transplanting young seedlings in rows along with compost or without a small amount of chemical fertilizer.

First, SCI was started by the late elderly woman called Mama Yehanusu Atsbeha had a good result. She planted the seedlings in a 5*5 m area in a field leaving a hand-space of 25 to 30 cm between plants. She also broadcasted seeds of the same finger millet variety directly into the rest of her field and she had applied compost to the entire field. The results were impressive. At an early stage, the plot of transplanted crop looked sparse; but later on the plants became dense with many tillers, each having longer, denser fingers (panicles) than on the seed-sown plants in the rest of the field. Mama Yehanusu got a yield equivalent with 7.6 tha^{-1} from the transplanted crop, while the rest of the field gave yield equivalent to 2.8 tha^{-1}. Moreover, it didn't only overcome the rainfall disturbance but also improved weed management.

The agricultural experts and many neighboring farmers were present when Mama Yehanusu harvested her crop. Not surprisingly, many farmers began adopting "her" way of raising finger millet seedlings before the start of the main rainy season. They have shown that Mama Yehanusu's field was not a "one-time" success. The average yield from fields of transplanted finger millet was 4.5tha^{-1} while with conventional broadcast type of sowing average yields remained at around 2tha^{-1}.

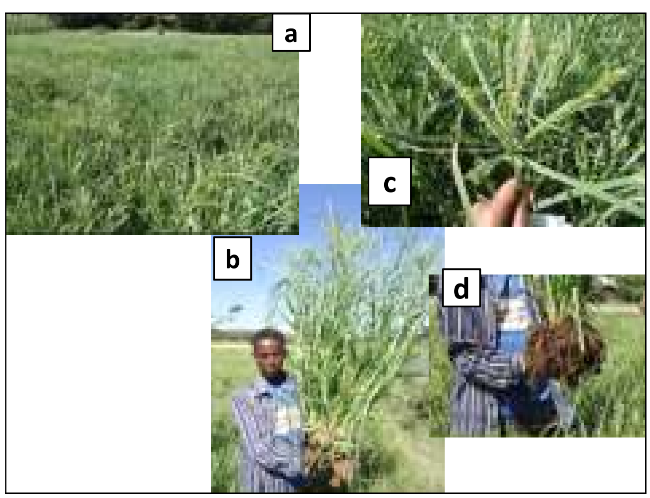

Figure 57: Finger millet in TM (a - good performance field; b - tiller and physical appearance; c - spike; d - root system)

[7] SRI was developed in 1980s in Madagascar through the efforts of Fr. Henri de Laulaniè, S.J. (Japan Association of the System of Rice Intensification, 2012)

Through using SCI in teff, farmers were getting yields of 2.5tha^{-1} or more. Teff grown with traditional management absorbs the bulk of household labor for land preparation, sowing, weeding and harvesting. But with SCI, weeding and harvesting is much easier and quicker.
In addition to yield enhancement, transplanting seedlings of finger millet, sorghum and other crops has shown various advantages for adapting to climate change.

- Using SCI, crops become more tolerant of extreme weather events such as dry spells during the rainy season and even to water-logging when there are storms;
- Labor is reduced while crop performance improves, because:
  - transplanting makes inter-row and inter-plant weed control easier so that farmers can use simple weeding tools to cut the roots of the weeds so they form a mulch over the soil and decompose to boost soil fertility, or
  - weeds are collected for animal feed which is much needed while the movement of animals for grazing is restricted during the growing season;
  - when the soil is aerated that stimulates the growth of plant roots and benefits aerobic soil organisms;
  - harvesting by sickle is easier as plant growth is more uniform and the mature panicles do not get tangled up as in the case of broadcast sown field;
- Establishing the crop in rows allows efficient use of inputs (compost, fertilizers, etc.), which are placed alongside the seed or in the hole with the seedling rather than being spread randomly over the whole field;

These changes in agronomic practices help farmers mitigate or adapt to changes in climate because seedlings can be raised in small protected areas with an efficient use of available water about one month before the main rainy season is expected. Then, when the main rainy season has started and the soil is moistened, the seedlings are transplanted to a field which is clean from weeds. As clearly seen in Figure 61, when transplanted, the roots grow bigger and deeper, making better use of the moisture at lower soil depths; and there are more strong productive shoots, the tillers. Overall, the general aim of the SCI technology is to enable farmers to improve their productivity while adapting to climate change.

8.2.2 Bee-Keeping adaptive to Climate Change

Many families in different agroecological zones of the Horn of Africa keep bees because the honey, beeswax, and bee colonies are good source of income. It contributes significantly to the households' food security. It provides income generating opportunities for unemployed youth, women, and other institutions such as monasteries. These days, there are different people in different agroecologies bringing innovative practices to improve beekeeping and its products.

i. Climate change adaptive Beehives

Due to the changing climate, communities in moisture stress areas are facing serious problems which include that bee colonies are abscold their hives due to shortage of beeforage and water; changing weather conditions; unsuitable beehives; etc. Although agricultural extension service insist for the modern beehives but most of the farmers decline from adopting the modern beehives; they prefer the traditional beehives instead. These people adopt the traditional beehives in order to guarantee their bee keeping without any challenge. This is because these beehives are cheap; easy to produce or buy and manage; they have high temperature insulating nature, etc. Traditional beehives are made from: 1. hollow wood; 2. sticks tied together and plastered with cow dung and/or mud; 3. Made from cattle dung mixed with straw; and 4. Adapted beehive i.e. made from cattle dung mixed with tef straw plastered on wooden frame shape. They have smaller in their size as compared to the modern ones.

According to the evaluation of farmers, the bee colonies in the "adapted" hives are stronger than those kept in the modern ones. They agreed that the "adapted" hive has created comfortable environment for the bees to easily regulate the temperature inside their hives during cold and warm seasons, and even between day and night. Farmers also commented that bee colonies live longer and make honey faster in the climate adaptive beehives. The honey can be harvested twice a year: once just after the start of the main growing season in July when crops and many other herbaceous plants flower and the other at the end of the growing season around November (Hailu et al., 2012b).

ii. Bee colony multiplication adaptive to the specific agroecological niche

Another challenge for farmers is colonies introduced from far locations do not adapt the new location. They abscold or die or become weak in producing honey. Then, they come up with an idea of multiplying by splitting the local bee colonies already adapted the niche. Splitting of a colony becomes possible if all three types of cells (drones, workers and queens) on the brood frames. Farmers prepare 2 or 3 queen rearing beehives which are traditionally made from gourds. The combs with the three types of cells are divided among these special beehives: each colony is focused around its egg-laying queen with its workers. During the colony splitting process, the farmer leaves one of the new bee colonies in the old site and puts the hive with the old colony some distance away. Each colony is about 50 to100 meters apart from each other.

The establishment of new bee colonies is usually done at the beginning of the main rainy season from about the end of June to the middle of July or from the end of August to the first week of September. The new bee colonies stabilize when they are created in good time. Training in making bee hives, the expert farmer bee keepers also train other innovator farmers on how to split their own bee colonies so that can increase the number of hives, particularly in areas where beekeeping has not previously been practiced, or the first colonies have escaped. This is helping their bees to adapt to their new environment. Therefore, many farmers are seeking training skills on bee colony splitting.

iii. Minimizing beeforage gap through planting flowering trees

Due to land degradation and climate change beeforage has deteriorated very much by type and density. It is true landscape diversity reduced significantly. Farmers in Tahtai Maichew, Tigray, have identified many of the plants preferred by bees as forage including their flowering time. This helps the farmers and other interested in beekeeping groups to establish productive bee colonies. The most important bee forage plants are those that flower during the dry season or beeforage gap as this is the feed shortage period for beekeeping. Moreover, farmers have identified those plants that give the best quality honey. These include herbs and shrubs called girbiya (*Hypoestes forskolei*), siwa qarni (*Leucas abyssinica*) and tebeb (*Becium grandiflorum*) and the widespread small acacia tree lahai (*Acacia lahai*). Fruit trees, such as banana (*Musa sapientum*), citron/tringo *(Citrus medica)* and sweet orange (*Citrus simensis*), are also important sources of bee forage (Figure 62). Farmers collect seeds, raise seedlings and plant them in individual farms as well as community land and enclosures. Having local experts and innovator farmers taking the lead in the expansion of bee keeping is helping more farmers increase and diversify their source of income and family nutrition. It is also bringing back and helping conserve the local biodiversity.

Figure 62: A few examples of important bee forage plants

iv. Honey production in arid and semi-arid areas

Beekeeping in arid and semi-arid areas is better in areas bordering highlands. It helps the bee colony to have cooler weather, good bee forage and moisture. The arid and semi-arid areas are also with special beeforage plants. Pastoralists give special respect and attention to these plant species. This type of bee keeping is found in the agro-pastoralist areas. However, one very good lesson we learned from the practices of Somaliland is mobile beehives. The bee hives are moved from drier into moist areas or where they can find bee forage and water. They also do not harvest honey from the beehives whenever the season is drier and difficult for the honey bees to survive. There is a similar practice in the Dallol areas of Afar that they move beehives to a better place during dry period.

8.3. Smallholder agricultural practice in Somaliland

The climate in Somaliland reflects arid and semi-arid. Water is very scarce for all types of economic activities; on top of the existing climate change, sun light in the semi-arid part of the Horn of Africa is very strong for all plant, animal and human let alone for fruits and vegetables. However, there is attractive market for all types of agricultural products. It motivated agro-pastoral farmers to produce by overcoming all types of challenges.

Figure 63: Fruit tree plantation in Somaliland

Figure 64: Smallholder vegetable production in Somaliland

Limited water is available in shallow distances (Figure 67), this shows more water is needed to compensate the high rate of evapo-transpiration but they are trying their best to grow fruits and vegetables (see figures 63, 64 and 65) with the available water only. However, soil crusting and salinity developed on their farms (see figure 69). Even if irrigation farming is to be tried out in the dryland areas, human and animal encroachment especially camel and birds are very destructive to these green pockets farm areas because they attract human and animals.

Figure 65: Traditional water use efficiency techniques in Somaliland

Figure 66: Goat and sheep manure application in fruit and vegetable farm in Somaliland

The limited numbers of agropastoralists in Somliland are careful and use animal manure especially from goats and sheep to enhance soil fertility and keep soil moisture (Figure 66). However, many people do not have the awareness about the use of animal manure because there are unlimited piles of animal manure accumulated in the premises of the port of Berbera (see figure 68). On one side, it will improve the productivity of the soil by conditioning the soil in this dryland area. On the other side, if this manure is not used for farming or soil amendment through time it will be a problem when it reachs the coastal/ beach area. However, they lack technical skills about proper manure and pesticide or IPM utilization and management; efficient use of moisture in their fruit and vegetable farms; integrating farming system with animal feed and live fences etc.

Figure 67: Some examples of the available water sources in Somaliland

Figure 68: The unlimited animal manure accumulated in the premises of the port of Berbera

Figure 69: Crusting and salinity developed through application of unknown chemical fertilizer type and amount on vegetable production in Somaliland

Vegetable and fruit growers are using different types of pesticides to reduce the risk of insect pest infestation. However, they do not have any technical support on pesticide utilization and handling, checking their expiry dates and use of protective measures when they apply in their farms (see figure 70).

Figure 70: Pesticide packaging is thrown everywhere in Somaliland

8.4. Vegetable production in Arid and Semi-Arid areas of Afar, Ethiopia

Communities living in moisture stress areas are food and nutrition insecure. They lack access to crop production because of unfavorable climatic conditions to grow diverse varieties of crops. In these areas water use efficiency technologies are helpful in order to improve food and nutrition availability and security.

Trench gardening is vegetable growing technology in deep trench in order to use moisture efficienctly. The trench is laminated with thick plastic and filled by a mix of compost, manure and fertile soil. It is one of the agro-ecologically best fitting technologies to make vegetable production possible in moisture stress areas of Afar Regional State. It is found at the foot-hills of the Rift Valley escarpments of the highlands of Northern Ethiopia. Trench gardening was piloted in Koneba and Semurobi Gela'elo districts through the financial support of the Bread for the World/ PADD via PELUM Ethiopia and Best Practice Association (Figure 71). It was started in four individuals in two locations first but spread very quickly into many indivuals within six months. This methodology was tested, made vegetables available and accepted by agro-pastoral communities living with no sufficient moisture, land, or soil to grow.

This technology became popular in empowering women, elderly people, children and people with disabilities because of its applicability around homestead areas and it needs less water or moisture. This technique is meant to assist farmers, agro-pastoralists, urban areas and development practitioners all over the country and beyond to use trench gardening as a means to achieve food and nutrition security for moisture stress areas. Therefore, it is suggested to scale it up/ out among different partner organizations and it might description of the technology need to be translated into different languages in order to become most useful for grass-root communities in similar environmental conditions. However, before that it is suggested to conduct further study on the moisture intake status and nutritional status of respective families.

Figure 71: Effects of vegetable production by trench gardening

CHAPTER NINE

WHY IS AGROECOLOGY THE BEST OPTION FOR FARMERS?

9.1 Agroecological approach has diversified options

Agroecology is an age old practice with over 7,000 years (Tewolde, 2006) with a list of options characterized by smallholder management, local knowledge, practice, and innovation in improving soil fertility, productivity and production through different practices. For example, Hawariya and Weldu of Tahtai Maichew District in Tigray Region have improving their soil by bringing fertile soil from silt accomulating sites, tree canopies, mulching etc. (Hailu et al., 2012). The soil bank practice of a couple (Haregu Gobezay and Kalayu Hafte) from Rama is another good example of collecting fertile soil from the nearby river bank; Araya W/Aregay also called the soil maker (Figure 72) of Tahtai Maichew District also created soil for his stony landscape by crushing the soft rocks and built terraces by big hard-rocks. He uses mulch of leaves and tree branches to improve the organic matter of the newly created soils (Hailu et al., 2012).

Figure 72: The soil making process by farmer Araya in Tahtai Maichew

Gebreyesus Tesfay and his neighbours who live in Tahitay Maichew Kewanit area produced best quality of tea manure and pest and disease controlling liquid solutions from plants with soft and bitter leaves together with animal urine and dung, respectively. The tea manure solution is applied to all type of vegetables and fruit trees by diluting with water at 1:10 ratio. One farmer from Bete Sema'eti village of Tahtai Maichew District who faces moisture retation problems to grow maize in his homestead area, as his homestead area is a bit slopy, built a series of micro-basins in his farm-plot to hold moisture. He observed that the moisture in these basins stayed longer while plots without micro-basins dried faster. Then, he built more micro-basins throughout the field and improved his production of maize and increased yield due to vigorous plant stands having more than one cobs.

Agroforestry, intercropping, mixed cropping and mixed farming are methods of crop diversfication where agroforestry is the best way of diversifying crops with fruits, vegetables, spices, field crops etc. This helps to increase food and feed availability, generate income, prepare different farm tool, conserve soil and water etc. In some areas, planting of *hanfets* (barley and durum wheat mix) helps to minimize risk of crop failure by heavy rain or disease/pest infestation.

Climate variability causes prolonged droughts and erratic rainfall that can reduce water retention capacity of the soil; increases soil erossion and biodiversity loss; decreases agricultural productivity. As a result, farmers may be forced to shift from growing of long season crops to short season crops by transplanting to enhance adaptation capacities to the problems of climate change and get better production i.e. the production of the late Mama Yehanusu by transplanting of finger millet was 7.6 $mtha^{-1}$ as compared to broadcast with 2.8 t/ha (Hailu, et al, 2013).

Generally, there are many good examples where innovative agricultural works make life easy. The family of the late Beyene Tadesse of Hitosa (Arsi) didn't have farm land than their homestead but the family managed good life by renting farm-land and improving their crops by bioslurry application. Smaller land holding can generate higher income as long as there are creative minds. This kind of activity is observed in many parts of the country and families such as in the upper Rift Valley, Wollo, Tigray, etc. and individual farmers like Tilahun Teka, Tesfanesh Bekele, Atnafu Lema, etc. of Wendo Genet. At the beginning, their land holding was <0.25ha but their creativity makes their land enough through agroecological means (Hailu and Yohannes, 2016). According to Roland (2020), small farms are considered more sustainable than large farms and many studies confirmed that their sustainability is not due to their size but their management. Therefore, agroecological practices in general contribute to water use efficiency and the building up of healthy soils, thereby increasing the resilience of the people and the environment as there is low utilization of external agricultural inputs and these practices improve moisture retention capacity of soils (Hailu 2010; Edwards et al. 2010). Moreover, it improves the life of land users with small land holding. For them, land is their sole capital as source of employment, income, food, feed, and secure their decision making.

9.2. Agroecological approach strengthens food and nutrition security, and food sovereignty

The multifunctionality of agroecology is indicated by its contribution to food security, nutrition security, food sovereignty and sustainability. Under smallholder faming system, all elements of agro-ecology mainly efficiency, recycling, diversity, synergy, human and social value, circular economy, culture and food traditions are highly reflected. Farm diversification is an indicator of maintaining nutrition. Results of studies by Hailu (2010) showed that yields of crops were obtained from plots applied both chemical fertilizer and compost were significantly higher (p>99%) than those obtained from fields where no inputs wereapplied (Table 6) which is an indication of the weak production capacity of the soils (Hailu, 2010) while smallholder farmers are experienced with different means manure, soil and water conservation (SWC), mineral fertilizer, compost, combination of two or more inputs, etc. to heal the soil and increase crop production (Hailu, 2010). This shows that small farms are more sustainable than large farms due to their management (Roland, 2020).

Table 6: Grain and straw yield (kg.ha-1) by crop and treatment in Tahtai Maichew district

Treatment/crop type	**Teff**		**Barley**		**Faba bean**	
	Grain	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**
Control	872^{b}	2812^{c}	2173^{b}	7092^{b}	3334^{b}	17065^{b}
Mineral Fertilizer	1120^{a}	3485^{a}	3025^{a}	9275^{a}	3832^{ab}	19728^{ab}
3.2 $t.ha^{-1}.yr^{-1}$ compost	935^{b}	3195^{b}	2325^{b}	8575^{a}	3886^{ab}	19822^{ab}
6.4 $t.ha^{-1}.yr^{-1}$ compost	1113^{a}	3428^{a}	2950^{a}	9225^{a}	4230^{a}	21039^{a}

Means within the same collumn followed by same letter (s) are not significantly different each other at P<0.05 confidence interval

Source: Hailu (2010*)*

Food sovereignty is about deciding what to produce and/or what to use as input to enhance farm productivity and crop protection. Farming practices in the developing world in general and Ethiopia in particular, indicate that soil fertility management and farming practices are as per farmers' preferences and decisions. Crop rotation, animal manure, planting multi-purpose trees, and composting are strongly implemented by over 80% of farmers, of which about 87% of the farmers practice crop rotation every year (Table 7).

Table 7: Farmers' responses (n=171) to different soil fertility management practices

R.N	Traditional Practices	Regular users	Partial users	Tend to leave	Non users
1	Fallow	1.7	0.6	5.3	92.4
2	SWC *(Kirit or Gedeba)*	83.5	14.1	1.2	1.2
3	Crop rotation	87.1	12.9	0	0
4	Animal manure	81.9	15.2	1.2	1.7
5	Planting multi-purpose trees	38.6	56.7	2.3	2.3
6	Compost	38.6	59.6	1.7	0
7	Mineral fertilizer	60.2	15.2	22.2	2.3
8	Mixed cropping (intercropping locally called *Ziniq* and/or *Wahrar*)	12.3	17.5	0	70.1
9	Leaving crop residues in the field	0	22.8	47.4	29.8

***Source**:* Hailu, 2010

As shown in table 3, 39 % farmers of the study area mix compost and/or animal manure with mineral fertilizer, 24 %of the farmers prepare and use compost only, and 13.5 percent use animal manure only in their fields. There are only 13.5 % farmers who use mineral fertilizer alone in their fields. About 10 % do not use any type of input in their farms because they have fertile fields and they don't need any input to be applied (Table 8).

Table 8: Input application per number of farm plots at yearly level

R.N.	Plots applied with	CO	AM	CO+AM+MF	MF	No input
1	100% of their plots	14 (34.1)	0 (0)	28 (41.8)	19 (82.6)	0
2	About ¾ of their plots	13 (31.7)	0 (0)	16 (23.9)	*4 (17.4)	0
3	About ½ of their plots	10 (24.4)	15 (65.2)	11 (16.4)	0 (0)	0
4	About ¼ of their plots	2 (4.9)	8 (34.8)	6 (9.0)	0 (0)	0
5	Some times	2 (4.9)	0 (0)	6 (9.0)	0 (0)	0
6	No application	0 (0)	0 (0)	0 (0)	0 (0)	**17 (100.0)
	Total	**41 (24.0)**	**23 (13.5)**	**67 (39.2)**	**23 (13.5)**	**17 (9.9)**

Key: Co - compost only; AM - animal manure only; MF - mineral fertilizer. *These are some times supported with crop rotation i.e., when they cropped their plots with legume crops such as faba bean. **These plots are fertile and supported by other soil fertility management practices.

Due to the existing mixed farming system, Ethiopian farmers want to produce food and feed from their farm. But farmers' preference in farm production varies based on crop type. Yield is the function of complex interaction systems in the smallholders farming systems but economists, experts, researchers, and policy makers apply simple calculations to represent yield and income components only while Ethiopian farmers see yield in relation to the advantage of their cattle because they are very important in their life. The yield preference varies based on the crop type. About 70 % of the farmers preferred to get a higher yield of faba bean grain than straw because the straw is not palatable for animals while 70-74 % of respondent farmers prefer (Table 9) in producing equal amount of straw and grain of barley and teff because they need the straw to feed their cattle especially oxen (Hailu, 2010).

Table 9: Farmers' response (n=96) for yield preference based on crop type in TahtaiMaichew District

Crop type	Yield preference		
	High grain than biomass	**High biomass than grain**	**Equal both grain and biomass**
Teff	8 (8.3)	17 (17.7)	71 (74.0)
Barley	15 (15.6)	14 (14.6)	67 (69.8)
Faba bean	67 (69.8)	-	29 (30.2)
Total	**90 (31.2)**	**31 (10.8)**	**167 (58.0)**

Source: Hailu, 2010

Enset is one of the best examples of food and nutrition security and food sovereignty crop (Tesfaye and Zerihun, 2018). For most of Southern Ethiopia it is all. It is an identity of the local people that is rich or poor. If there is no enset in the field of a family, it would mean that there is no life in the house. According to Ato Weldehana, enset is the major asset in their area and it plays a major role in reducing poverty and it is the primary crop for ensuring food security. It is highly adored as a tree that keeps hunger away because it is available in all seasons and moisture conditions. It is source of local knowledge and practices. Generally, growing enset is not only good sign of food and nutrition security but also food soverignity and local level adaptation strategy to climate change.

9.3. Agroecological farming system improves ecosystem health

The indiscriminate use of agricultural pesticides puts natural resources in general and agricultural production in particular as well as agroecosystem as a whole at high risk. The unwise use of pesticides is known to harm vital ecosystem services such as natural biological pest control agents, pollinators, and nutrient recycling systems. Excessive use of insecticides can also result in secondary pest outbreaks. Furthermore, intensive use of highly hazardous chemicals causes frequent poisoning and chronic health problems, particularly for smallholder farmers. Women and children in rural communities are often directly or indirectly exposed to toxic pesticides in farm fields especially in irrigation areas.

Generally, in Somaliland pesticides are available in shops while in Ethiopia they are delivered through legally registered organizations. In both countries, mainly Somaliland there is weak follow up on their application, storage and expiry dates. In Somaliland, unbranded pesticides are purchased in markets and applied without any protective measures. A female vegetable farmer near Hargeisa reported that she has applied for more than 10 times on her tomato before was taken to the market. As there is no agricultural extension service in Somaliland, no one gives them advice about the precautions that should be taken in using or handling of pesticides. However, in Ethiopia, the extension people try to inform and advice farmers. In all countries, farmers do not care whenever they mix with water and applying whithout protective measures and they do not know what will happen to their health. The major agrochemical consumer areas in Ethiopia are the upper Rift valley areas between Adama and Arba Minch areas, where commercial vegetable and cotton production is common. There are different types of agro-chemicals (pesticides, herbicides, insecticides, fungicides, nematocide, etc.) provided in order to protect agricultural production from pests, disease, and weed. However, they are problematic in many ways. 1. They are hazardous to human and animal health. Applying without personal protective devices is a sign of low or no awareness about the negative effect of these agrochemicals. 2. Whenever applying, they are killing all useful and harmful insects including pollinators. Moreover, they are killing honey bees resulting in loss of honey production. 3. These agro-chemicals are expensive not only to purchase but also expensive to remove when they are expired than their cost of importation.

Given the challenges to global food security, food safety and environmental protection, the sustainable intensification of agricultural production is emerging as a major priority for policy makers and international development partners through managing agricultural ecosystems combining intensification of crop production with reduction of pesticide use. Adoption of Integrated Pest Management (IPM) by smallholder farmers is deemed a vital component of such intensification efforts (FAO, 2011). Whenever agriculture is being practiced, the safety of human, animal and environment should be taken into consideration otherwise practicing agriculture without safety is risky. Studies show that there are good opportunities. First of all, many agricultural extensionists have understood their negative effects on the pollinators especially honey bees and decided application of agro-chemicals is a final resort (Hailu, et al., 2012). At the same time, the crop protection section of the agricultural extension has an IPM component and skill. The Tahtai Maichew District of Tigray has decided not to apply pesticides without consulting responsible experts.

There are many types of effective crop protection mechanisms practiced and accepted by farmers. Most of them are agro-ecological knowledge and practices while others are farm innovations by individuals or groups while some of them are introduced through the extension. These technologies are important because they are: environmentally friendly; no health hazards; easily available and economically feasible; socially acceptable; no or less effects on non-target pests as they are biological products etc. Some of the effective, sustainable, and locally tested agro-ecological practices are discussed in this study (please refer chapter seven).

9.4. Agroecological system builds resilience capacity and enhances adaptive capacity to climate change

Nowadays, land degradation and climate change nexus is affecting all life forms negatively. There are many events attributing to climate or weather change in their area that: unexpected rain with varying quantity and effects; elongated dry season resulting in crop failure; unusual water shortage and drying up of riversetc. It is evident that agro-ecology builds resilience and enhances adaptive capacity to climate change. Agro-ecological practices can be adopted by smallholder farmers with minimum expenses in the face of the climate change such as controlling land degradation through integrated soil and water conservation methods. Some of the effective agro-ecological practices are: The work of Haregu Gobezay in overcoming the challenge of the negative effects of climate change (Bisrat et al., 2015). The effective work of communities in Hararghe, Abreha We-Atsbeha and Kembata areas to overcome the challenge of land degradation combined with climate change. The kelela (area closure of Afar, Somali and Somaliland) gives breathing space whenever drought has occurred. These all activities are signs of resilience by farming communities to overcome the challenges of climate change. They boost human food and animal feed in addition to the stabilization of their respective ecosystem.

Biodiversity enhances the resilience of agro-ecosystems as it provides "insurance" or "a buffer," against environmental fluctuations, as different species respond differently to fluctuations, leading to more predictable ecosystem responses. For example, application of compost creates conditioning of soil by retaining moisture. It not only enhancing soil fertility and boosting agricultural production but also resist dryness of soil when there is failure/shortage of rainfall. When rainfall suddenly quite crops applied with organic input such as compost wilt two weeks later than crops applied with chemical fertilizer (Hailu, 2010).

9.5. Agroecological farming system encourages knowledge sharing and intergenerational link

Ethiopian agriculture is dominated by family farming with a close interrelationship between farms, family, and locality. It links production system with economic, social, and cultural aspect of life. The challenges related to succession concern considers agriculture not only as an economic activity and occupation, but can be considered as indicators for different processes related to and with impacts on the future of rural areas. Family farm succession is an intergenerational transfer of a farm and involves three interrelated processes: inheritance, succession and retirement (Errington 2002). The relationship between the generations and how this withdrawal is handled is therefore also a central aspect of the succession process that is a younger generation takes over from the older. Therefore, questions related to social and cultural changes between generations are relevant for understanding the challenges in the succession process.

The crucial factor for succession concerns the preferences and resources of the families involved in agriculture including how it is conceived by the potential farmers or successors and their families; what kind of life they want to live; and also what kind of alternatives they consider. The challenge observed is due to the psychology in the modern educational system which does not encourage and interact with rural farming. At the same time, the country is challenged by high youth unemployment, who is interested in the urban lifestyles.

The following are good experiences of knowledge sharing and intergenerational linkage created to be worth noting systematically broken the present educational system, which abort the new generation from their fathers. Wolero Habebo (68), is one of the reknown agroecology practicng farmer in Kachabira Woreda of Kembata Tembaro Zone. He has strong desire to ensure sustainability and the continuation of implementing ecological agriculture in his family. One of the worries against his wish has been low attention and interest of the youth for ecological agriculture. He discussed the issue within the family and negotiated with his sons: Kasahun (22) an elementary teacher and Meharu (21) TVET student to engaging them in ecological agriculture and share the benefits from the practice, and in turn ensure the continuation of their career and sustenance of ecological agriculture. The father and the two sons have made an agreement to shoulder different responsibilites: sons to work on the farm like any other laborers; and the father to fix payments like to other workers in addition to covering education and training costs of the sons. Another family of Woldeamanuel Feleke (62) in Kacha Bira has the same experience with his son Selamu Woldeamanuel (21). Samuel Doleso (58) and his wife Abebech Sendano (48) are hard working and effective ecological farmers in their community of Mierab Badwacho woreda of Hadya Zone. Inspired by their parents' commitment and hard work all their children (Mishame (28) and Debritu (24)) are first year university students in Wachamo University; Hana (22), Ersado (19) and Belay (16) all high school students are actively participating and helping their parents wholeheartedly.

All parents mentioned above have ensured intergenerational learning and linking of ecological agriculture in both Hadya and Kembata Tembara zones and enabled to see some youth appreciating and practicing ecological agriculture together with meeting their educational interest through distance learning. Enset is one of the best examples of all inclusive farming of all social groups in the farming knowledge and practices. It is a source of local knowledge. First of all, they keep the agronomic practices to fertilize and keep proper hygine to strengthen its resistance to disease. Whenever *Enset Bacterial* Wilt occurs, the local community controled by different mechanisms of protection like, cutting, burn or bury the affected enset in isolation.

9.6. Agroecological system harmonizes all agricultural practices

Land degradation and declining agricultural yield indicate that increasing agricultural production to feed the ever-increasing population is a must. Therefore, governments are strategizing to increase food production through different global initiatives such as Asian Green Revolution, Sasakawa Global 2000, Millennium Village project and AGRA back up by international donors. All of them are known for the excess use of high external inputs in the name of improved technologies (Menale and Zikhali, 2009). Sasakawa Global 2000 program was started in 1995 by the Ministry of Agriculture to boost food crop production using chemical fertilizer along with high yielding varieties (HYVs) and pesticides through credit schemes and subsidized prices. But the subsidy on chemical fertilizer was withdrawn and yet the price had more than doubled (Hailu and Sue, 2006). Then, many farmers were heavily in debt and withdrew from the fertilizer schemes. Moreover, when farmers are hit by drought crops applied with chemical fertilizer got yield less than farmers who uses low external agriculture production system (Hailu, 2010).

Table 10: Agricultural input utilization by type and region

S. N.	Type of input used	Region	2014/15		2015/16		2016/17		2017/18	
			Amount used	Area (ha)	Amount used	Area (ha)	Amount used	Area (ha)	Amount used	Area (ha)
1.	Biofertilizer (sachet)	SNNPR	27,053	6,763	51,078	12,770	113,462	28,366	68,667	34,752
		Oromiya	24,782	6,196	59,596	14,253	63,230	15,808	83,290	20,823
		Amhara	21,288	5,322	32,202	8,051	10,479	2,620	53,402	13,447
		Tigray	2,512	628	4,050	1,013	5,741	1,435	2,028	507
	Total		**75,635**	**18,909**	**146,926**	**36,086**	**190,156**	**47,539**	**207,387**	**69,529**
2.	Compost (“000” tons)	SNNPR	384	156	181	156	1,400	83	8,210	776
		Oromiya	37,426	11,214	42,489	1,326	41,300	2,634	35,016	2,079
		Amhara	41,354	1,348	47,099	1,348	43,300	1,135	40,902	1,039
		Tigray	4,824	639	12,095	-	3,300	-	17,312	-
	Total		**82,813**	**13,356**	**129,046**	**2,829**	**153,600**	**3,853**	**173,115**	**3,895**
3.	Lime supplied (quintals)	SNNPR	6,656	330	6,073	304	28,601	980		
		Oromiya	12,148	763	17,400	894	18,479	854		
		Amhara	1,172	21,849	9,574	24,036	1,231	26,212		
4	ISFM	Amhara				20		14		

Source: MoA, 2018

On the other hand, ecological agriculture says there is a need for an alternative agricultural system that addresses many of the constraints faced by resource-poor farmers and at the same time ensures environmental sustainability. Such alternative includes use of compost, which contains sufficient amount of almost all macro- and micro-nutrients for plant growth. Therefore, it provides sufficient food and other goods and services that are economically efficient and profitable, socially responsible, and environmentally sound involving a combination of inter-related soil, crop and livestock production practices (Menale and Zikhali, 2009). However, compost, as one of the options has insufficient amounts of the required amount of P for plants (Hailu, 2010), which can be supplemented by chemical fertilizer until the P level of compost is boosted. This indicates the need for the intermarriage of the conventional and ecological farming than inclining to one side (Tables 10 and 11). A study conducted in Axum area also showed a combination of 10-25% recommended fertilizer with 3.2 and 6.4 tha^{-1} compost application gave the highest yield of tef (see section 6.2). Therefore, the need for harmonization in order to satisfy the input needed by selecting the most cost effective, locally available and enhance ecosystem health.

Table 11: Fertilizer consumption by region for the years between 2011-2014 in “000“ quintals

S.N.	Regions	2011	2012	2013	2014	2015
1	**Oromia**	1,886.7	2,551.4	2,793.0	2,913.7	2,894.2
2	**Amhara**	2,015.7	2,282.3	2,441.8	2,967.6	3,083.4
3	**SNNP**	960.8	660.6	1,149.0	1,664.1	1,165.5
4	**Tigray**	352.3	516.2	580.1	613.7	476.7
5	**Others**	290.4	343.0	328.5	429.1	407.8
	Total	**5,505.8**	**6,353.4**	**7,292.4**	**8,588.2**	**8,027.7**

Source: MoA, 2018

Unlike reports and the push of the agricultural extension, the government of Ethiopia is diversifying its input utilization, which means even though high focus is on the utilization of chemical fertilizer other means are not cancelled (Tables 10 and 11). Rather, they are in the annual plan of all regions and weredas. Please see tables 19 and 20 shown above for four regions (Amhara, Oromiya, SNNPR and Tigray). Existing practices show that fertilizer utilization is between 5.5 and 8.6 million quintals; compost utilization in the four agricultural regions account for 82 to 173 million metric ton; biofertilizer also between 75,000 to 207,000 sachets per year is being used. This is one good opportunity at the policy level to be used in order to harmonize the conventional and existing agroecological practices. However, synthetic fertilizer application is still not to the required standard of the Ministry of Agriculture (Kefyalew, 2011).

CHAPTER TEN

THE POLITICS OF AGROECOLOGY

10.1 Agroecology in the policies of countries

10.1.1 National policy

The existing policies, regulations, and strategies issued in Ethiopia support agro-ecological practices under smallholder farming system in one or another way. The Conservation Strategy of Ethiopia (CSE) formulated in 1995, provides an adequate umbrella strategic framework, detailing principles, guidelines, and strategies for the effective management of the environment. The Environmental policy of Ethiopia states that farmers are free to use their own input and seed (FDRE, 1997). It was issued in 1997 to promote sustainable social and economic development. It has incorporated a number of sector specific and cross-sectoral environmental policy provisions including soil husbandry and sustainable agriculture; genetic resources and ecosystem diversity; water resources; energy resources; Urban Environment and Environmental Health; Atmospheric Pollution and Climate Change, etc.

The government of Ethiopia in its effort to develop the country, has decided to give high focus in transforming the Agriculture system by issuing a new strategy called Agriculture Development-Led Industrialization (ADLI) and pertinent programs in the areas of: Natural Resources Management (watershed management, sustainable land management, etc.), irrigation development, food security, social safety net, climate change, disaster prevention etc. The Ethiopian Agricultural Sector Policy and Investment Framework (PIF): This strategy is issued in 2010 and planned for 2010-2020 based on ADLI, PASDEP and GTP II. The specific objectives are: Increasing productivity in smallholder agriculture; and sustainably increase rural incomes and national food security that includes nurturing the environment, eliminating hunger and protecting the vulnerables against shocks. The extension service also support farmers for a better agricultural yield through facilitating service and delivering different technologies (Kristin et al, 2010). Moreover, the Ethiopian Parliament has endorsed Ethiopian organic production legislation (FDRE, 2006) with the following objective that is facilitating international recognition and acceptance of the Ethiopian organic agriculture system.

The Ethiopian government has declared its Climate Resilient Green Economy (CRGE) strategy to be carbon neutral middle income status before 2025 (EPA, 2011). It is an initiative to protect the country from the adverse effects of climate change and to build a green economy that will help realize its ambition of reaching middle income status before 2025. However, there are minor problems during the implementation of policies, rules and regulations, and strategies such as insisting farmers to use fertilizers and improved seeds. The Growth and Transformation Plan (GTP) is now envisaged with the aim of making the country reach middle income status by 2025 following Green Growth Development model.

For that matter, the government has given due and serious attention to addressing the challenge of soil health and fertility decline to enhance agricultural productivity for ensuring food security. To this effect, the Federal Ministry of Agriculture and Natural Resources recently developed 10 years' comprehensive soil improvement strategic plan of Ethiopia. In the strategic document, details of soil level and policy level challenges were identified and interventions aimed at addressing them have been described by giving much attention to the importance of agro-ecological practices (MOANRs, 2018). At the same time the government of Ethiopia has set a new office to develop a land use plan for the country. Then, farming system will be enhanced by land use plan, which is very important for agro-ecological practices.

Global agreements and policies also encourage the implementation of local initiatives. In September 2011, the Food and Agriculture Organization of the United Nations (FAO) began planning with other UN agencies, including UNEP, for the establishment of a Global Soil Partnership to support and facilitate joint efforts towards sustainable management of soil resources for food security and for climate change adaptation and mitigation (FAO, 2012). Global instruments that have been adopted by many governments-including the Convention on Biodiversity, the International Treaty on Plant Genetic Resources for Food and Agriculture and the IUCN Red List-provide for inter-country collaboration in the conservation of natural resources.

As it is well known, Ethiopia is very much endowed with diverse agro-ecological conditions, which is believed to give the people high opportunity to grow crops and different varieties. The government of Ethiopia and the people by large are also making a lot of efforts to establish policies and strategies, design appropriate programs, and implement them as effective and efficient as possible. The National Biodiversity Strategy and Action Plan (NBSAP) was prepared in 2005 (IBC, 2005) to "address interlinked issues comprising biodiversity protection and management for food security, health and livelihood improvement of the Ethiopian population especially the rural communities (farmers and pastoralists) whose survival depends on the use of natural resources". At the same time, NBSAP attempts to meet the planning requirement of the Convention on Biodiversity as well as the national biodiversity conservation needs.

10.1.2 International agreements related to agroecology

The Africa Union has adopted Agenda 2063 (AU, 2015), as a collective vision and roadmap for the next fifty years and therefore commit to speed-up actions to: reduce the imports of food and raise intra-Africa trade in agriculture and food to 50% of total formal food and agricultural trade. The controversy is according to the agenda 2063 it says "Africa's agriculture will be modern and productive, using science and technologies, innovation and indigenous knowledge" at the same time it also said that "The hand hoe will be banished by 2025".

The SDG of the United Nations has 17 goals and 169 targets (Derek et al., 2015). Some of the goals such as Goal 2 (end hunger, achieve food security and improved nutrition, and promote sustainable agriculture) and Goal 12 (ensure sustainable consumption and production patterns). Generally, in one way or another SDG goals refer sustainable development in different ways.

Some of the targets indicate successful agricultural production system. By 2030, doubling the agricultural productivity and the incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, etc. (target 2.3); by 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality (target 2.4); by 2020 maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks (target 2.5); by 2030 halve per capita global food waste at the retail and consumer level, and reduce food losses along production and supply chains including post-harvest losses (target 12.3); by 2020 achieve environmentally sound management of chemicals and all wastes throughout their life cycle in accordance with agreed international frameworks and significantly reduce their release to air, water and soil to minimize their adverse impacts on human health and the environment (target 12.4); by 2030 substantially reduce waste generation through prevention, reduction, recycling, and reuse (target 12.5) and refer encourage companies, especially large and trans-national companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle (target 12.6).

10.2 Agroecology in the policies of development institutions

This refers to the implementation of agro-ecological practices by different institutions which includeis religious, government, Civil Society Organizations (CSOs), research and academic institutions. This means how far do these institutions recognize and practice agro-ecological systems based on their policies to enhance agricultural production through soil fertility, crop protection and diversification. It also includes about their focus on research and training of staff, students and/or beneficiaries in agro-ecology related topics/courses. Some outstanding examples are:

i. Religious Organizations

All visited religious institutions mainly monasteries and faith based development organizations consider agro-ecology as a package in their development work. They have activities related to their agro-ecological farming practices. Some of the projects under implementation include: Integrated Rural Development Project; Rural Livelihood Improvement Project; Dry land Development program; Food security and Livelihood; supporting smallholder farmers on the sustainable ways of enhancing soil fertility, etc. Some of the institutions have their own demonstration plots while others rather use Farmers Training Centers and Nursery sites. All the visited farms in monasteries do not apply external/synthetic inputs to improve their soil fertility or crop protection. If they need to enhance the soil fertility they apply farm yard manure from their domestic animals and human.

Some of the good examples are: St. Haik Etifanos with organic fruits and vegetables in Tehuledere wereda, Wollo; St. Mariam Diwo with crop and vegetable production and Gunda Gundo fruit production in Tigray. The Ethiopian Kale Heywet Church has a well-coordinated work on the ground. They have the following specific projects under implementation: Farming God Ways (Conservation Farming); Agroforestry, Compost, Green Manure Crops; and Integrated Pest Management Practices. Kale Heywet church have also produced two publications entitled: ***Farming God's Ways: A field Guide*** and ***Food Security through Sustainable Agriculture.*** The second publication has some best practices in Food Security project work of some Civil Society Organizations in Ethiopia. They have also a manual on Highland Fruit production.

ii. Public Institutions

- **Agricultural extension**

The Ministry of Agriculture in Ethiopia took agroecological system seriously. For that matter, the Soil Fertility Improvement Directorate has three sub-teams one of them is natural fertilizer sub-team. In collaboration with other partners it has formulated 10 years soil strategy plan, which include many components of agroecology such as natural fertilizer and problematic soils in the strategy. At the same time, there is good experience of advocating farmers to practice Integrated Soil Fertility Management (ISFM) for sustainable crop production and productivity which is suited to agro-ecology and farming system. Moreover, vermi-composting is also promoted very seriously to enhance the use of natural fertilizer. It is in collaboration with ISFM/GIZ, ATA, Regional Research Institutes, Universities, Regional Bureau of Agriculture, etc. through demonstration and scaling up approaches.

- **Research and academic institutions**

There are many experts engaged in conducting research and demonstration activities on different components of agro-ecology. But agro-Ecological Farming System is not given sufficient attention except conducting specific research and teaching courses. Almost all the higher academic institutions in Ethiopia have agriculture faculties teaching for 1st degree and 2nd degree; and even 3rd degrees in agriculure. Budget is not encouraging and not sustainable. All these institutions have their own demonstration plots for their agricultural research and training with much attention to artificial inputs. It is also one good opportunity all universities have animal husbandry as fattening or dairy even including poultry but there is no appropriate animal waste management in order to recycle as a resource. The food wastes from cafeterias do not have their own proper waste management systems. Almost all higher academic institutions have a program working with farmers through Community Service and Technology Transfer programs; however, most of them do not consult farmers instead they expect farmers as recipients than working partners. There are limited universities, colleges and staffwith good working relation and communication with farmers and extension people.

iii. Civil Society Organizations (CSOs)

Almost all the CSOs contacted are implementing some elements of agroecological system. They build the capacity of their own staff, local communities, and local agricultural experts and demonstrate through applying soil fertility enhancement activities, diversification and/or crop protection measures to increase agricultural yield. Some CSOs such as: REST, LWF, ISD and GIZ have development programs related to agro-ecological practices. They implement agroforestry practice, area closure, soil and water conservation, small-scale irrigation, composting/vermicomposting, distribution of improved local cow bread, inter-cropping, manure and fallowing. Their beneficiary farmers increase their yield ecologically by applying some activites of the components mentioned above plus their own practices such as manure, planting legume trees, crop rotation, inter-cropping etc.

LWF implement Conservation Agriculture, application of improved agricultural technologies (green manure, compost and wise use of chemicals), demonstration plots, crop rotation and green manure application like legume crops (faba bean and cowpea*)*, intercropping of cereal with legume plants, strip cultivation, crop rotation, mulching and use of crop residual, increase of soil cover plants, plantation of legume species on ridges, etc. ISD promotes seed saving, crop diversification, bioslurry, push pull technology, intercropping and manure activities/projects. Beneficialryfarmers enhance their yield and soil fertility ecologically by applying manure, planting legume trees, composting, crop rotation, intercropping, and using liquid fertilizer. GIZ is currently implementing a project called ISFM (Integrated Soil Fertility Management) with many distrcts in different regions of the country of Ethiopia. At the same time, there is a project called Nutrition Sensitive Agriculture, mostly promoting production and diversification of food items at family level.

Most of the CSOs have know-how about agroecological practices because they are implementing and promoting soil fertility enhancement, crop protection, diverisification, adaption to climate change, environmental protection, etc. However, the main challenges observed in accomplishing agro ecological farming are: low understanding of the term agro ecology at all levels; some of the ecological projects are donor driven; lack of political willingness because they promote utilization of external input; lack of participatory research and collaboration; outbreak of crop pests and weeds forcing farmers to use chemical pesticides and herbicides; climate change impacts; there is no information who is doing what because of the weak information dissemination system etc.

Our studies showed that different institutions are implementing some agroecological practices depending on their policies. CSOs implement as pilot project depending on donor fund. They have their own annual plan to boost agricultural production through compost, legume crops, bio-slurry, bee-keeping, poultry, dairy farms at household level, intercropping of legume with cereal crops, crop diversification and rotation, enclosure and stabilization of marginalized lands, use of animal manure in farm field and crop residues, and plantation of legume plants along farm ridges.

Public institutions depend on government fund allocated budget for research and demonstration. All insitutions practice some components of agroecological practices. Churches and monasteries have better opportunity to implement and sustain agroecological projects. However, all the institutions lack coordination and collaboration. Therefore, we suggest that promoting effective and practical coordinated agro-ecological systems to facilitate wider adoption of the practices through: massive public consultation, workshops and seminars; training and awareness creation; networking at different levels; strong lobby, advocacy and campaign. There is good opportunity for collaboration among different partners to implement agro-ecological practices under smallholder farmer management. We have also observed that there is huge problem of duplication of efforts and resources as most did not know who is working on what. This is because there is no proper linkage among partners. There are no organized information hubs that we were not able to easily access the required information. No existence of an entity that can coordinate the various interventions at local and national level is observed as a critical challenge. Therefore, it is recommended that there is urgent need by partners to be coordinated, build their technical and human capacity; and enhance their information sharing systems.

10.3 The wrong debate: who feeds the complex world?

These days, population pressure combined with land degradation and climate change are affecting human survival (Oxfam Novib, 2011). Climate change is becoming unfolding threat to all living things and agriculture due to extreme weather occurrences, unreliability of rainfall etc. It disturbes farmers in planning their normal farming practices (Hailu, 2012), and rainfall fluctuations and unreliability destined to crop failure and then famine. Then, feeding the complex world is becoming a challenge. Therefore, it is better to assess and review the debate "who can feed the world" in reference to the debate on paper, research stations and in the real ground with an emphasis of production challenges in both the small scale farmers and large scale farming practices.

A study by IFAD (2011), advocates that smallholder farmers can feed the world with examples from South America and Africa. There are also many other questions i.e. Can Organic Farming Feed the World? Can GMO feed the World? Can Conventional Agriculture feed the World? On the other hand, others answer positively or negatively deliberately to fulfill their agricultural politics. However, this is a wrong debate because:

- **First**, the target of these questions by pro-industrial agriculture people is inclined to their own business politics to convince policy makers based onmathematically calculated yields from closed research stations against smallholder and agroecological farming systems. They are assisted by multi-national companies to push policy makers to issue regulations on agricultural extension in favor of their businesses such as seed companies including GMO pushing to knock-out local seeds from the system in order to handcap smallholder farmers.
- **Second**, the question should be who is realy feeding Ethiopia or the world than who can feed the world? Who is feeding the world is more of current scenario and little focus to sustainable agriculture and food systems. Modern/Industrial Agriculture, which is not only young and delicate to adapt climate crisis but also limited coverage while traditional and ecological agriculture are still producing about 70 % of the total food produced in the world. Most of the present farming systems, ecological farming, have been practiced for thousands of years with ample options, which have allowed traditional farmers to optimize their harvest and the multiple use of the landscape with limited environmental impact (Altieri, 2000). It enhances the multifunctional nature of agriculture with regard to ecology, knowledge management, and social organizations with sustained yields (Altieri, 2000; Harwood, 1979; Reinjtes et al., 1992).
- **Third**, "Who is the world" should be clear with the complex interconnection of ecosystems. Nature includes all life forms above-and below- ground, visible and invisible etc other than human being. Entities are useless without interconnections and complementing between and among each other. The biggest home for most of the life forms is soil. Maintaining soil health and fertility is imperative for agricultural sustainability. Therefore, feeding human being is the smallest portion of nature. Among the different agricultural activities, agroecological farming consists much of the ecosystem in general. However, it is very complex for reductionist researchers and experts to measure all natural

components in the ecosystem against the simple calculation of the yield, labor, finance, basic social services, etc. of the conventional agriculture is simply calculating the benefits for human life by ignoring the rest. Then, before we go which one feeds the world it is better to identify who is going to be fed? In many of their writings, nobody has stated the complexity of our planet as the home of many macro- and micro-organisms.

Although this is narrow thinking agroecology has a better chance of feeding world human population. It is true that human population has increased tremendously. But, if agricultural yield is declined due to land degradation, it will never sustain and feed human population without maintaining the health of the soil, which is attached with other life forms. However, many governments are planning to increase food production through different global initiatives such as Asian Green Revolution, Sasakawa Global 2000, Millennium Village Project and AGRA with back ups from international companies. All of them are known for the excess use of chemical fertilizers and pesticides in the name of improved technologies (Menale and Zikhali, 2009). But, the subsidy on chemical fertilizer (Urea and DAP) was withdrawn while the price had more than doubled, which created many farmers heavily in debt and withdrew from the fertilizer schemes. Moreover, many parts of the Ethiopia were also hit by much reduced rainy or by drought and yields declined (Hailu, 2010). Higher production with high external input was true only at the beginning (Hailu, 2010). The Asian Green Revolution led to dramatic production increases in the 1960s and 1970s but it was not sustainable. Rice yield growth in Asia declined sharply in the 1980s, from an annual growth rate of 2.6% in the 1970s to 1.5% during the period beginning in 1981, owing partly to increasing prices of chemical fertilizer and agrochemicals (Menale and Zikhali, 2009); the study in Kabete, Kenya, showed that treatments with only mineral fertilizers initially out-yielded the no-input and farm yard manure (FYM) treatments but later tend to decline rapidly (Nandwa and Bekunda, 1998). Similar result was reported indicating lack of sustainability under high input agriculture that rice yield has stagnated and declined during the Asian Green Revolution; wheat supplemented with FYM show high and stable yield unlike the inorganic NPK treatments which has resulted in significant yield decline over the last 14 years (Bhandari et al., 2002). Moreover, Green Revolution had adverse human health and environmental impacts, polluted water bodies, and degraded soils, biodiversity loss, salinization and increased pest resistance, has required more or stronger agrochemicals to sustain yield levels. All these costs have not been properly internalized in the calculations of production costs of the Green Revolution model (Menale and Zikhali, 2009).

However, ecological approach with 6.4tha-1 compost application on teff, barley and faba bean give higher and sustainable yield and cost effective than recommended chemical fertilizer (Hailu 2010). Research results in Tigray Region of Ethiopia reported that ecological/ sustainable agriculture are more resilience to climate change because crops treated with compost wilted two weeks later than chemical fertilizer when rain was withdrawn. Moreover, it is evident that diverse farming and healthy soil are more resilient to climate change.

As nature is very diverse and interconnected, who feeds the world is the prior concern. Therefore, all options should be on the table rather than taking one side of the diverse agriculture systems. Recently, AGRA has recognized the importance of the farmer-owned seed systems and has adopted the integrated soil fertility management practice/method as its core approach (ACBIO, 2012). If it is narrowly seen and meant who feeds human being? The answer is still it is on the shoulder of the smallholder farmers. Farmers are ethically, morally, socially and religiously prepared for feeding the world. Therefore, decisions about farming system belongs to the smallholder farmers that is this decision is the right of the land user we called “Food Sovereignity.”

CHAPTER ELEVEN

AGROECOLOGY PERFORMANCE EVALUATION

According to Gliessman (2016) there are five levels of agroecology, leaving Level 0. The first three levels (1-3) of the five describe the steps farmers can actually take on their farms while the next two levels go beyond the farm level to the broader food system and societies in which they are embedded, and point towards food sovereignty for everyone involved. Although, the five levels taken together can appear to be a stepwise process, in reality, multiple entry points and interacting processes can work in harmony with agroecology to ensure food system transformation (IPES-Food 2018). Therefore, the performance evaluation will focus on the elements of agroecology related with the following five steps. These are:

- **Level 1:** Increase the efficiency of industrial and conventional practices in order to reduce the use and consumption of costly, scarce, or environmentally damaging inputs. Here, the element of agroecology is **efficiency**.
- **Level 2:** Substitute alternative practices for industrial inputs and practices; helping in replacing external inputs and environmentally degrading products and practices by those more renewable, based on natural products, and more environmentally sound. The relevant element of agroecology is **recycling**. Some good examples of substitution are use of nitrogen-fixing cover crops and crop rotation.
- **Level 3:** Redesign the agroecosystem so that it functions on the basis of a new set of ecological processes. The focus is on prevention of problems before they occur, rather than trying to control them after they happen. The elements of agroecology related to this level are **diversity**, **synergies** and **resilience**. Good examples by Gliessman (2016) are the reintroduction of diversity in farm structure and management through such actions as ecologically-based rotations, multiple cropping, agroforestry, and the integration of animals with crops.
- **Level 4:** Re-establish a more direct connection between those who grow our food and those who consume it (Gliessman, 2016). The agroecological elements included here are: **Co-creation and sharing of knowledge, culture and food traditions, and circular and solidarity economy**. Food system transformation occurs within a cultural and economic context. At a local level, this means that those who eat must value food that is locally grown and processed, and support farmers with their food purchases who are attempting to move through Levels 1–3 (IPES-Food, 2018). Sovereignty can begin to appear for the farmer, the eater, and everyone in between as direct relationships turn into stable food networks.

Level 5: Build a new global food system, based on equity, participation, democracy, and justice, that is not only sustainable but also helps restore and protect earth's life support systems upon which we all depend (Gliessman, 2016). The agroecological elements included here are: **human and social values,** and **responsible governance**.

The elements mentioned in the three levels (1-3) above are to be implemented at farmers' level i.e. land users while the next levels (4 and 5) are beyond the farm scale to implement (FAO, 2014), because it requires linkage with other external bodies to accomplish. Therefore, the evaluation will be dependent on the farm and landscape levels. The Tool for Agroecology Performance Evaluation (TAPE) of FAO (2019) is appropriate for evaluating the performance level of some selected agroecological practices mentioned in this document. Therefore, we are going to evaluate the three levels depending on the following criteria (elements of agroecology). Being smallholder farming has something already done in the ground the scoring starts from 1 (lowest) to 5 (highest).

These are:

1. Efficiency (FAO, 2019):

The primary goal of change at this level is to use industrial inputs more efficiently so that fewer external inputs will be needed and the negative impacts of their use will also be reduced. Most conventional agricultural research has taken place at this level, through which considerable modern agricultural technologies, inputs, and practices have been developed. This research has helped farmers maintain or increase production through such practices as improved seeds, optimum planting density, more efficient pesticide and fertilizer application, and more precise use of water. So-called *precision agriculture* is a recent focus of research at Level 1. Although this kind of research has reduced some of the negative impacts of industrial agriculture, it does not help break its dependence on external material inputs and monoculture practices. Breaking away from this dependence is a key goal of food sovereignty, while retaining the logic of industrial agriculture is at the heart of such practices as *sustainable intensification (*Gliessman, 2015).

- **Use of external inputs:** Take into account all inputs needed for production, including energy, fuel, fertilizers, seeds, young animals, straw for artificial insemination, workforce, phytosanitary substances etc. Reduced synthetic fertilizer application and use of animal feed: Reduced application of synthetic fertilizer or nitrogen leakage; more efficient use of animal feed.
- **Management of soil fertility:** Minimum synthetic fertilizer is used because soil fertility is managed through a variety of organic practices.
- **Management of pests and diseases:** Reduced application of herbicides, fungicides, insecticides, fumigants, or use of veterinary drugs such as pests and diseases are managed through a variety of biological substances and prevention measures; very minimum chemical pesticides and drugs are used.
- **Reduced use of: water use while maintaining/increasing yield through improved practices; energy use** in farming by improved technology; **seed use:** improved or efficient storage and use of planting materials, which result in better crop growth and reduced early mortality. For example: optimal seed spacing such as SCI/ SRI. **Reduced waste:** reduction of losses at harvesting, processing, storage or post-harvest through improved technologies and equipment.
- **Improved plant variety and animal breed:** improved variety or breed that reduces the use of external inputs of at least two of the following categories: water, pesticide, fertilizer, seed and/or drug.

Evaluation scoring: Lowest score (1) means high use and dependency on purchased external inputs for their farm and households while the highest score (5) means very minimum use and dependency on external inputs, which means they use local resources for the farm and households. List of activities related to this scoring are mentioned above this paragraph.

2. Recycling (FAO, 2019):

The goal of this level of transition is to replace external input, which is intensive and environmentally degrading products and practices with those that are more renewable, based on natural products, and more environmentally sound. For instance, some farmers use nitrogen-fixing cover crops to replace synthetic nitrogen fertilizers, some use rotations and companion planting as natural means of controlling pests and diseases instead of industrial pesticides, and others use composts for improving soil fertility and soil organic matter management. However, at this level, the basic agroecosystem is not usually altered from its more simplified form; hence, many of the same problems that occur in industrial systems also occur in those with input substitution *(*Gliessman, 2015).

- **Recycling of biomass and nutrients:** No waste at all because waste, residues and by-products are recycled for alternative soil inputs. Substituting synthetic fertilizers through alternate amendments example compost, manure, cow dung, legume crops, acidic/ saline soil management, etc.
- **Water saving such as** water harvesting or saving and various practices to limit water use. **Recycling of waste water** for agricultural use, agricultural water reuse e.g. recycling domestic, municipal, industrial waste water, and use of desalinated water.
- **Management of seeds and breeds:** seeds/animal genetic resources are self-produced, exchanged with other farmers or managed collectively, ensuring enough renewal and diversity.
- **Cover crops for pest management:** planting cover crops specifically for weed control or pest reduction. For example, Nitrogen fixing cover crop and leguminous green manures, crop sown for mulching.
- **Climate mitigation through alternative practices:** e.g. Increase soil carbon stock through reduced or no tillage, deep rooting plants, agroforestry, biochar, humus build up, controlling land use change.

Evaluation scoring: Lowest score (1) means no local renewal or recycling of local resources and biomass practice practiced while the highest score (5) means very high recycling or renewal of local resources/ biomass practices for farm and household use. List of activities related to this scoring are mentioned above this paragraph.

3. Diversity (FAO, 2019):

Diversity refers to the diversity of species, functions, genetic resources and thereby the overall agroecosystem biodiversity in time and space at field, farm and landscape scales.

- **Diversity of crop, animal, trees and other perennials at field, farms and landscapes.** For example,
  - **Improving local seed/breed diversity:** Development of local breeds/varieties, local seed system, seed banks, participatory breeding, promoting local crop varieties etc.
  - **Integrating locally adapted crops:** traditional crop varieties alongside high yielding varieties etc.
  - **Spatially diversified farms**: Introducing diversity over space by multi-, poly-, or inter-cropping etc. Multi-habitat approach that is increasing land-use diversity or diversity at the landscape scale.
- **Diversity of functions (activities, products and services):**
  - **Crop rotation from simple to complex level:**
  - **Natural pollinators:** Enhance local and natural pollinators (and their habitats) for example flower strips, flower meadows, honey production etc
  - **Diversification of diets and consumption:** Promotion of diversified locally produced healthy diet through a diversified food production system. Diversification of crop production with a nutrition focus, promotion of local food, gardening etc

Evaluation scoring: Lowest score (1) means there is almost no practice of diversification is maintained and/or enhanced while the highest score (5) means there is maximum diversity is maintained and enhanced in farms, households or landscape level. List of activities related to this scoring are mentioned above this paragraph.

4. **Synergies (FAO, 2019):**

Positive ecological interaction, synergy, integration and complementarity among the elements of the agroecosystems such as animals, crops, trees, soil and water; some of them are:

- **Crop-livestock-aquaculture integration:** For example, animals are exclusively fed with feed produced on the farm, crop residues and by-products and/or grazing, all their manure is recycled as fertilizer and they provide more than one service (food, products, traction, etc.). Diversified farming system including both crops and livestock.
- **Rotational/regenerative grazing:** It is used in improving grazing methods/management to improve soil quality and forage yield. **Soil-plants management system:** Crops are rotated regularly and intercropping is common (or rotational grazing is systematic). Little or no soil disturbance.
- **Integration with trees (agroforestry, silvopastoralism, agrosilvopastoralism):** Many trees (and other perennials) provide several products and services.
- **Connectivity between elements of the agroecosystem and the landscape:** The agroecosystem presents a mosaic and diversified landscape, many elements such as trees, shrubs, fences or ponds can be found in between each plot of cropland or pasture, or several zones of ecological compensation. Incorporating non-crop plants in agroecological systems for ecological functions such as conservation, water quality, or pest management example cover crops (example desmodium) for weed suppression, as a pest repellent plant, fixes nitrogen and serves as fodder; planting of natural fence such as cactus (feed, food, fence etc).
- **Other landscape planning and synchronized landscape activity leading to improved agricultural ecosystem services:** For example reforestation/restoration/ preservation of natural habitats with clear benefits for agricultural production, diversified land-use or alternate flowering at the landscape level to improve pollination services, windbreaks, soil erosion control with example using hedgerows, half-moon, terracing, stone bunds etc.

Evaluation scoring: Lowest score (1) mean no ecological interaction, integration (synergy) practiced or enhanced within the farm or landscape while the highest score (5) mean ecological integration or synergy is common in most farm or landscape holdings. List of activities related to this scoring are mentioned above this paragraph.

5. **Resilience (FAO, 2019):**

- Promotion of the resilience of agroecosystems to specific disturbances (windfall, storm, heavy rain, winter freeze, floods, draught, wildfire), including developing framework on the recovery of one or more ecosystem services in response to that disturbance. For example, watershed management, water budgeting, flood control etc.
- Development of adapted system to future conditions. Improved locally adapted varieties/breeds to future climate conditions. It includes environmental resilience and capacity to adapt to climate change: Higher environmental resilience and capacity to adapt to climate change.
- **Livelihood resilience:** Mechanisms to reduce vulnerability such as diversification of production; access to markets, access to local food; diversification of work type etc. Minimum indebtedness and higher, diversified and stable income source at farm/ household, levels etc. Stability of income/production and capacity to recover from perturbations, they fully and quickly recover after shocks/perturbations.

Evaluation scoring: Lowest score (1) means there is no capacity of or options for copping with shocks or disturbances whilst the highest score (5) means with lots of options or very high resilience level to shocks or disturbance environmentally, farm level, family level and landscape level. List of activities related to this scoring are mentioned above this paragraph.

6. Culture and Food tradition (FAO, 2019):

This refers to the:

- Availability of appropriate diet and nutrition awareness.
- Existence and practice of local or traditional identity and awareness.
- Degree of use of local varieties/ breeds and traditional knowledge for food preparation

Evaluation scoring: Lowest score (1) means there is no appropriate diet, nutrition awareness and practing traditional knowledge for food preparation while the highest score (5) means there is higher appropriate diet, nutrition awareness and practicing traditional knowledge for food preparation in the households or community. List of activities related to this scoring are mentioned above this paragraph.

7. Co-creation and sharing of knowledge (FAO, 2019):

- Existence and use of platforms for the horizontal creation and transfer of knowledge and good practices including involvement of women.
- Access to agroecological knowledge and interest of producers in agroecology. Agroecological knowledge and practices may also be called in some other ways, and producers may know and apply them without knowing the word “Agroecology”. Focus on the actual practices and knowledge for the evaluation, and not on the formal knowledge of “Agroecology” as a science. Willingness to implement innovations, facilitating knowledge sharing within and between communities and involving youth and women i.e. intergenerational linkage.
- Degree of participation or inter-connectedness of producers in networks and grassroot organizations.

Evaluation scoring: Lowest score (1) means there is weak or no horizontal creation and transfer of knowledge and good practices through network among and between generations while the highest score (5) means there is very high horizontal creation and transfer of knowledge and good practices through network within communities and between generations. List of possible activities related to this scoring are mentioned above this paragraph.

8. Human and social values (FAO, 2019):

- Level of women’s empowerment on decision making and access to resources.
- Labour (productive conditions, social inequalities) that is working condition fairness; social and economic proximity between farmers and employees.
- Level of youth empowerment and emigration; wish to improve their livelihoods and living conditions within their community with agriculture.

Evaluation scoring: Lowest score (1) means there is unfair working condition, weak or less women and youth empowerment, they do have less hope at their locality while the highest score (5) means there is fair working condition, high women and youth empowerment, they do have high hope at their local livelihood. List of possible activities related to this scoring are mentioned above this paragraph.

9. Circular and Solidarity Economy (FAO, 2019):

- Products and services marketed locally.

- Level of networks of producers, relationship with consumers and free from intermediaries including women participation.
- Extent of local food system that is level of a community's self-sufficiency for agricultural and food production.

Evaluation scoring: Lowest score (1) means producers are not networked, no relationship with consumers and highly influenced by intermediary for marketing while the highest score (5) means producers are highly networked, with strong relationship with consumers and are free from the influence of middle men for accessing market i.e. producers are self-sufficient. List of possible activities related to this scoring are mentioned above this paragraph.

10. Responsible Governance (FAO, 2019):

- Producers' empowerment with their rights or bargaining power, improve their livelihood and develop their skills i.e. both women and men.
- Producers' organizations and associations – transparency and cooperation for information, market access, capacity building etc. i.e. both men and women.
- Level of participation, decision-making and influence of producers in governance of land and natural resources i.e. men and women

Evaluation scoring: Lowest score (1) means community members are with low level of participation, decision-making and influence in governance of land and natural resources while the highest score (5) means community members are with very high level of participation, decision-making and influence in governance of land and natural resources for both men and women. List of possible activities related to this scoring are mentioned above this paragraph.

Table 1 shows the list of different agroecological practices implemented by Ethiopian smallholder farmers against the above criteria based on the TAPE tool by FAO (2019). It shows to what extent the local practices fulfill the five elements, which are included in the first three levels of Gliesmann (2016). It is simply to indicate how different agroecological practices can be evaluated.

Table 12: Agroecology Performance Evaluation of selected practices based on TAPE Tool (FAO, 2019)

No	Smallholder managed agroecological practices	Elements of agroecology/ score					Value	
		Eff	Rcy	Div	Syn	Resi	25	100(%)
1	Konso: The land of home-driven Integrated Soil and Water Management	4	4	4	5	3	20	80
2	Integrated soil and water conservation in Hararghe	3	3	3	4	3	16	64
3	Abreha We-Atsbeha: There is no marginal land under agroecological practices	3	3	3	4	4	17	68
4	Socially enhanced community managed hillside development	2	3	2	3	3	13	52
5	Area closures in pastoralist and agro-pastoral areas	2	2	2	2	2	10	40
6	Beles: Multifunctional plant for true agroecological practice	3	2	1	4	4	14	56
7	Gedeo traditional agroforestry	3	3	4	5	5	20	80
8	Enset based farming	4	3	4	5	5	21	84
9	Composting	4	4	2	4	3	17	68
10	Integrated soil fertility management (ISFM)	4	4	3	4	3	18	72
11	Ecological soil acidity treatment	4	2	2	3	3	14	56
12	Smallholder agricultural practice in Somaliland	3	2	2	3	3	13	52
13	Ecological Cotton production	4	2	2	3	3	14	56
14	Ecological Urban Agriculture	4	4	2	3	3	16	64

Key:- *Div (diversity), Syn (Synergies), Eff (efficiency) Rcy (Recycling), Resi (Resilience)*

Based on the agroecological performance evaluation tool shown above: enset based farming with 84 % took the lead; the second are Gedeo traditional agroforestry and traditional Konso Soil and Water Conservation practices with 80% each while the third group are Integrated soil fertility management (ISFM), Abreha We-Atsbeha: There is no marginal land under agroecological practices and composting practices which scored 72, 68 and 68 % respectively (Table 1).

CHAPTER TWELVE

SCALING UP/ OUT GOOD AGRO-ECOLOGICAL PRACTICES

Introduction

African agriculture in general and Ethiopian agriculture in particular is embedded with home-driven knowledge, technologies and practices that are accessible, affordable, easy and sustainable. Smallholder farming is still strong feeding its people and other creatures under a low profile. Therefore, the importance of the smallholder farming should be recognized, promoted and scaled-up/ out through collaboration and coordination. However, some scholars are advising to push smallholder farming system into the hands of corporate companies by ignoring its contribution in feed their respective countries. The tag of war is not how or who is going to produce but it is who is going to control our food system. No one is going to win in the wars for controlling our food systems because it will kill our survival in the middle. According to FAO (2015) agroecology offers the possibility of win-win solutions by building synergies, increasing food production and food and nutrition security while restoring the ecosystem services and biodiversity that are essential for sustainable agricultural production. However, at present there are opportunities and challenges in scaling up/out agroecology. These are:

12.1 Existing challenges for the scaling up/ out of agroecology

The existing challenges in scaling up/out agroecology are the following:

1. Land degradation

The already existing land degradation is the most common environmental problem in Ethiopia resulted in low and declining agricultural production and productivity, continuing food and nutrition insecurity, widespread moisture stresses and lowering of ground water, and biological degradation (WMO 2005). Therefore, it directly affected the type of plant grown on the area, reduced availability of potable water, lessened volumes of surface water, depletion of aquifers and biodiversity loss (Temesgen et al., 2014). Then as land is highly degraded environment becomes less resilient, more and more fragile and drought prone.

2. Higher attention for external input utilization by the agricultural extension

The so called modernity of agriculture supported by the agricultural extension and climate crisis affected different types of crop varieties restricting their cropping pattern. For example, farmers are shifting from long growing seasoned crops like finger millet, sorghum, maize etc. to short growing seasoned crops requiring low and short rain such as tef. The shift is not only by crop type but also by the diversity within the crop varieties. Moreover, the extension is also insisting farming families to go for high yielding variety (HYV) or improved variety of crops, which require high external input application. However, farmers are not comfortable on these crops because yields of improved crop varieties decline over years (Sue et al., 2010).

3. The move of multi-national companies

Multinational companies are trying interfering government policies in order to control the overall food system mainly seed such as engineered foods. Their entry is mainly through provision of research fund for agricultural production system with almost defined goals to provide their recommendation to their respective governments without consulting farmers.

4. Land grabbing and in-appropriate investment

Land grabbing is high in urban and rural areas. There is also a shift in land use in urban and peri-urban areas by removing of their traditional farming practices. The agricultural investments in most rural areas are clearing forest and its diversity, which are the sources of their food, nutrition, ritual and identity of the local people. These areas are rich in forest resources and then they are at risk due to logging especially in the name of investment business. Investors are practicing logging through forest clearance and then selling timber.

5. Agro-biodiversity decline

Ethiopia is endowed with great diversity of plant, animal and microbial genetic resources and provide good ecosystem services and contributes an estimated 4% to the GDP (EBI, 2014). But there are threats due to habitat conversion, unsustainable utilization of biodiversity resources, invasive species, replacement of local varieties and breeds, climate change and pollution (EBI, 2014). Biodiversity loss in the humid and sub-humid refers to the reduction of forest and non-timber forest product diversity. At the same time there is frequent forest fire occurrence in most part of the South west and western lowlands. It is one reason for the loss of different fauna and flora for example medicinal plants, wild edible species and bamboo.

6. Climate change

Although agroecological system perform better than any agricultural practices the concern about climate change are global and real (Ngaira, 2007). Third World countries like Ethiopia are threatened by the climate crisis because of their economic dependence on agriculture. Any crisis in climate significantly affect aggravate the decline of agricultural production, biodiversity loss; increased aridity; frequent occurrence of extreme heat events; changes in rainfall distribution, drought and flooding (Serdeczny et al., 2016); increased incidences of farm pests and diseases, over cultivation, food insecurity and poverty especially in Tropical regions (Ngaira, 2007). Artificial fertilizer application in crop production combined with unreliable rainfall is a problem that crop with chemical fertilizer dries easily than fields applied with farm yard manure or compost (Hailu, 2010). The effects of climate change in moisture stress areas manifested in drought (Serdeczny et al., 2016).

7. Infestation of new types of insect, pest, disease and weeds

These days in the face of climate change new types of weed, disease and pests are appearing; they highly affect crops, fruits and vegetables (Duressa, 2018) even grazing areas (Harnet, 2008). It insists the agricultural extension using hazardous chemicals for the outbreak of insects, pests and disease. For example, the locust outbreak in most part of East Africa is one example, which no one can escape. Livestock diseases are also problems in dryland areas. Some times the expansion of agricultural investment can increase the introduction and application of these chemicals.

8. Weak collaboration and coordination

There is weak culture of collaboration and collaboration not only among organizations but also within different units of the same organization such as universities, reseach institutions, agricultural extension and Civil Society Organizations (CSOs). Most civil society organizations promote agroecological system in their project areas. However, their relation with the agricultural extension is very critical that CSOs see government extension as obstacle for agroecology because they blame the extension service sector without involving them while implementing agroecological practices.

12.2. Existing opportunities for scaling up/ out agroecology

Although there are many challenges mentioned in the section above in promoting agroecological practices there are also lots of opportunities to further enhance agro-ecological practices in the Horn of Africa in general and Ethiopia in particular. Some of the existing opportunities are:

1. **Diversified agro-ecological zones and genetic diversities:** The Horn of Africa in general and Ethiopia in particular are endowed with different agroecological areas. They range from the Danakil Depression (120m below sea level) to the peak of the Ras Dashen (4,620m asl). This resulted in creating opportunities for genetic (fauna and flora) diversity, which gives production potential of different crops throughout the year. For that matter, it is known that Ethiopia is one of the oldest countries with diversified natural resources and socio-economy. Agro-biodiversity is very diverse from tree species to smaller herbs and animals (EBI, 2014). It includes edible herbs and under-growth spices as means of family food, nutrition, medicinal value, ritual, income etc.
2. **Existing good agroecological practices:** There are a lot of agroecological practices existing throughout the country. Please, refer practices covered in chapters from 4-8. These practices are proven to be productive through environmentally healthy practices. Such practices employed by farmers include ecofriendly and sustainable soil fertility management practices, growing healthy crops and plants, diversified fields with different crops, plants and animals.
    - There are many different ways of enhancing soil fertility and improving farm production through low external input utilization such as: compost, vermicompost, bioslurry, biofertilizer, crop rotation, mixed farming, legume, green manure integrated soil fertility management method etc. Farmers are combining local and modern knowledge to reduce the damage of insect pests and diseases. The agricultural extension, academics, research and farmers are continuously trying and practicing integrated insect pests, diseases etc. management practices to combat these increasing challenges. Farmers are also contributing their own to grow healthy plants through natural protection mechanisms.
    - The development of agroforestry is good example for a higher diversification at farms, homestead and landscape level. The traditional agroforestry in Gedeo, enset areas etc are best examples to see sustainable farming system that is agroecological practices.
    - Many good practices on adaptation to and mitigation of climate change: Even though we do not give much attention to local practices there are many accepted good practices that help to adapt and mitigate the adverse effects of climate change.
3. **The presence of many natural resource conservation practices:** These days area closures in both lowland and highlands as key means of restoring degraded lands as well as important rangeland management practices are becoming common practice. The expansion of area closures in arid and semi-arid areas in addition to its advantage to push for soil and water conservation, enabled to introduce cut and carry system of animal feed production management in these areas (for more information please see chapter 4).
4. **Availability of local/indigenous knowledge, practices and innovation:** There are communities and individuals with rich indigenous knowledge, practices and innovations throughout the Horn of Africa. The terraces of Konso, Deldal of Irob, the SWC of Abreha We-Atsbeha, Hararghe, Hadiya and Kembata connected with cut-and carry etc. are good examples. These are attached to the local knowledge of conserving soil and moisture, cropping pattern etc.
5. **Supportive government policy:** The government of Ethiopia is recognizing the importance of agro-ecological practices. There are many policies, regulations and strategies issued in Ethiopia which support the smallholder farming system. The ADLI, CRGE and the Environmental policy of Ethiopia state that farmers are free to use their own input and local seeds. The ten years soil strategic plan of the Ministry of

Agriculture has well addressed the importance of agro-ecological practices (MOANRs, 2018) that agro-ecological practices are dependent on the implementation of ecosystem based farming system. The extension services also support farmers for a better agricultural yield through facilitating services and delivering different technologies (Kristin et al, 2010). Moreover, the Ethiopian Parliament has endorsed Ethiopian organic production legislation. National and local regulations and incentives can also be used to promote improved soil carbon management practices for multiple benefits, with respect to existing land uses as well as restoration of degraded soils. However, there are problems during the implementation of policies, rules and regulations, and strategies such as insisting farmers to use fertilizers and improved seeds.

6. **High demand for ecological/ organic products:** There is an increasing demand for healthy food that is ecological organic products at local and global markets. Consumers push for ecological/ organic agriculture. For that matter healthy food starts from creating healthy soil and growing healthy plant/ crops.
7. **Increasing attention for urban agriculture:** Nowadays urban agriculture is increasingly getting attention in relation to its potential for poverty reduction, production of healthy food, reducing urban wastes etc. To this effect, Government of Ethiopia has developed Urban Agriculture Policy and Strategy as it has understood its importance in urban job creation and contribution to food security. For that matter, urban agriculture starts from using urban waste and then reducing pollution and contamination of air, water and soil.
8. **Widespread public institutions:** Public institutions spread throughout the country, which are good opportunities to enhance the scaling up of agro-ecological practices. The public institutions are:-
   - **Agricultural extension in the country:** Ethiopian agricultural extension is one of the appreciated practices in Africa. There are more than 3 development agents (DAs) in each village to support smallholder farmers. These DAs are also supported by many subject matter specialists/ experts at district level. Therefore, they can conduct participatory action research and demonstration with farming communities and the extension.
   - **Research and academic institutions:** Research and academic institutions in Ethiopia are spread throughout the country. There are over 50 public universities in which most of them are offering 2nd and 3rd degree programs in agriculture related fields currently. All regional states have research institutions and universities. Therefore, they can conduct participatory action research with farming communities and the extension service sector.
9. **Civil Society Organizations (CSOs) available in the country:** There are many Civil Society Organizations in the country promoting some components of agro-ecological practices. They are well distributed throughout the country. Although, they lack sufficient skill in agroecological knowledge and practices, they can be good opportunity for promoting agroecological practices by building their knowledge, skills and attitude through training and other capacity building mechanisms.
10. **Increasing donor interest in agroecology:** Different donors are interested in supporting components of agroecology such as soil health enhancement, conservation agriculture, regenerative agriculture, etc.

CHAPTER THIRTEEN

SUMMARY AND RECOMMENDATIONS

Smallholder farming system is the main source of livelihood, economy and employement of sub-saharan Africa (SSA) in general. The productivity and production of the sector is desperately very low. Consequently, SSA region is one of the most food and nutrition insecure regions in the world aggravated by untenable increase in human population. Thus, it is vital that agricultural productivity and production must be increased to feed the ever growing population and ever increasing demand but it is seriously challenged by low soil fertility, insect pests, weed, disease, climate change etc. Agricultural management for a higher production with accessible, affordable and sustainable means is demanding. Therefore, the importance of the smallholder farming should be recognized, promoted and scaled-up and/or scaled-out because many are convinced the agro-ecological farming approach feeding the complex world and research results are confirming the sustainability of small farms due to their close management. Some of the practices mentioned in chapters 4-8 are good and effective examples.

African scolars are not much supporting and improving smallholder agriculture with approperiate technologies; instead they see smallholder farmers to be recipients of external technologies attached to corporate companies such as external seed companies. Many corporate companies are not only hijacking farmers' rights on their farm practices but also interfer in the internal policies of countries. Based on the existing opportunities mentioned on section 12.2 of this study suggest the following recommendations:

1. Strengthening agroecology from isolated practices into agroecological system

Agricultural productivity and production are also indicating our soils require input to improve productivity and/or production. Therefore, it requires healing the soil to improve both soil productivity and production. But the question is choosing which practice and how to use. Applying higher external inputs can give good yield for a while but it is not sustainable because it feeds the plant not the soil like the Green Revolution approach. But when we feed the soil by applying more organic matter it maintains the soil health, its crop and production is sustainable. This is similar with the *Dutch saying* "*Fertilizer is good for the father and bad for the sons"* because feeding the soil is restoring soil health and fertility, which is feeding all, including feeding the plant. For that matter, evidences are confirming smallholder farms are most sustainable than big farms (Roland, 2020). The wide agroecological zones are endowed with genetic (fauna and flora) diversity, which gives production potential of different crops throughout the year. It is known that Ethiopia is one of the oldest countries with diversified natural resources and socio-economy (EBI, 2014). Agro-biodiversity is very diverse from tree species to smaller herbs and animals; edible herbs and under-growth, spices as means of family food, nutrition, medicinal value, ritual, income etc. Therefore, this study recommends:

1.1 Strengthen and promote effective agroecological practices

Promote the most effective and productive agro-ecological practices proven in addressing elements of agroecology at the same time enhance productivity and production. This study confirmed that there are lots of agroecological practices which include: i. creating healthy soil; ii. healthy crop/ plant protection; and iii. diversified fields with different crops, plants and animals etc. Agroecology begin by creating healthy soil such as compost, vermicompost, bioslurry, biofertilizer, crop rotation, mixed farming, legume, green manure etc, which recycle organic matter/ biomass and create synergy in order to bring sustainable production system. Many research results are also showing combining local and modern knowledge reduces the damage by insect pests and diseases. These can be implemented almost in all agro-ecological areas and earn trusted benefits for smallholder farmers and agro-pastoralists. Moreover, the lists of environmental protection practices (see chapters 4-8) are very important to improve natural regeneration everywhere.

1.2 Promote urban agriculture through proper urban waste management

By-products of the food items are creating critical problems in urban areas as urban waste. They are the source of pollution and contamination in air, water and soil and creating health problems. Reducing environment and public health risks through introducing composting practice as a means of urban solid waste management and as input for urban agriculture and greenery development and income generating scheme should be encouraged. Urban agriculture requires recognition by policy makers and support by research and extension in order to make urban agriculture more productive, reduce food insecurity and its potential for poverty reduction, reducing urban waste and urban job creation.

1.3 Recognize and promote local knowledge, practices and innovation

This study has identified and presented that there are many individuals and groups of people with rich local/indigenous knowledge, practices and innovations. Many appropriate practices on adaptation to climate change are also shown for example the terraces of Konso, Deldal of Irob, the SWC of Abreha We-Atsbeha, Hararghe, Hadiya and Kembata connected with cut-and carry etc. These are originated by their local knowledge in conserving soil and moisture, cropping pattern etc. Therefore, recognizing, popularizing and promoting local knowledge, practices and innovation are helpful not only in enhancing healthy food and nutrition security but also food sovereignty.

1.4 Promoting diversification

Families or communities who practiced crop diversification have proven with economic and social advantages for their households and landscapes. Most of these families developed their agriculture and livelihood most resilient as compared to other monocrop areas. The more they are diverse the more they are risk free. Therefore, it should be advised to diversify their overall farming system or household activities in order to avert environmental and human induced challenges.

2. Create organized capacity building programs

Promoting agroecology starts from awareness raising and capacity building for local people mainly for farming families, agricultural practitioners and their partners, which include producers, consumers, policy-makers, researchers etc. Capacity building programs based on the principle that participation and empowerment of food producers and consumers that are intrinsic components of sustainable agricultural development. The complex nature of agro-ecology requires trans-disciplinary approach of learning, teaching and research. Therefore, this study recommends:

2.1. Capacity building trainings should be practical because farmers trust when they see and practice.

2.2. Capacity building should be done directly to the implementing community members. That means if capacity building training is given directly to beneficiaries they will implement directly without knowledge gap.

2.3. Training programs should be designed in such a way that they can implement and transfer to other community members. It is through farmer-to-farmer learning and sharing approach and linked to each other as learning groups in order to further link and share their experiences at regular level.

2.4. Formal training programs in higher education institutions should be attached and connected with local community, which helps trainees to understand and build trust.

3. Strengthen lobby, advocacy and campaign programs

The best ways of influencing policy/decision makers is not only dependent on the dependable data and trusted evidences generated, shared and delivered to the right people but also how much is accepted and practiced by the local people. This will help in influencing policy makers in order to understand the contribution and sustainability of agroecological system to the economy of the country. If policy makers are well informed with proper knowledge and evidences they will not develop and pass policies unknowingly. Therefore, the study recommends:

3.1. Generate and share convincing evidences with policy makers from pilot projects accomplished at community level. It is fundamental to convince policy makers with trusted evidences that the reality of ecological agriculture is found to be emmense and encouraging in terms of their multifunctionality of the smallholder agriculture. Together with farmers, pastoral and agropastoral people organize field days for policy makers, experts, research, academic institutions etc. This will help policy-makers to directly meet with the real actors or beneficiaries of agroecological system.

3.2. Moreover, create relevant forums for regular lobby and advocacy on critical issues by involving policy makers.

4. Supporting good government policy

There are many policies, regulations and strategies issued in Ethiopia most of which support the smallholder farming system. Ethiopian government is recognizing and promoting ecological agriculture through different means. For example, the Ethiopian Government has endorsed different policies such as ADLI, CRGE and the Environmental policy of Ethiopia stated that farmers are free to use their own input and seeds. The ten years soil strategic plan of the Ministry of Agriculture has well addressed the importance of agro-ecological practices (MOANRs, 2018). Therefore, it is appreciate the government's efforts to assist farmers with proper policies, strategies and regulations and at the same time deliver our concerns on the minor problems during the implementation of policies, rules and regulations, and strategies. Therefore, this study recommends:

4.1. It is good to study the main challenging policies, regulations and strategies of the government together with policy makers and identify the implementation gaps.

4.2. Government should recognize the right of local people; their practice, culture, farming life, identity, the threat of land grabbing etc. Therefore, all families of agroecology should collaborate to insist and convince government to support local communities through policy backup.

5. Strengthen collaboration and coordination

There are many public institutions spread throughout the country, which are good opportunities to enhance the scaling up/out of agro-ecological practices. Ethiopian agricultural extension is one of the appreciated systems in Africa by allocating lots of human resources in each village supported by many subject matter specialists at district level to support smallholder farmers. There are also research and academic institutions spread throughout the country with high level qualified personnel in agriculture and related fields. However, the collaboration and work relation among research, academic institutions, CSOs and extension is seldom complements each other. Therefore, this study recommends:

5.1. As long as they are aiming to support communities they should complement each other and involve communities with their knowledge, practices and innovation.

5.2. Government and non-governmental organizations should actively collaborate to contribute in awareness rising for ecological agriculture at all levels. For example, supporting farmers field schools, knowledge exchange among farmers, promoting farm media (FM radio) to disseminate necessary information.

5.3. Improve collaboration and complementing of partners through capacity building; research etc. also convince policy makers to promote agroecological practices.

6. Involving Civil Society Organizations (CSOs) and their pilot projects

There are many Civil Society Organizations in the country promoting some components of agro-ecological practices. As they are well distributed throughout the country they can support promotion of agroecology in different agroecological areas. They can contribute their skill and capacity on agroecological knowledge and practices in order to implement in different locations. Therefore, it is recommended:

6.1. Create different critical forums in order to discuss, enhance their capacity and implement their agroecological projects. This will help them join efforts, resources, and stronger lobby and advocacy works at different level.

6.2. Conduct participatory research and generate evidences on the efficiency and significance of agroecological system in order to convince policy makers and donors through full participation of communties and extension in their pilot projects.

6.3. Organize field days for policy makers, experts, research, academic institutions etc. and let policy makers hear the truth from the farmers, pastoral and agro-pastoral community about the sustainability and benefits of agroecological system.

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PELUM Ethiopia

PELUM Ethiopia is working in sustainable rural and urban agriculture and natural resource management by increasing the capacity of its member organizations to connect and communicate with each other. PELUM Ethiopia believes that the burden and responsibility of feeding not only world human population for millennia but also all living things is on the shoulders of smallholder farmers and pastoralists. Therefore, if we do not improve the productivity and efficiency of our farmers and pastoralists, it will not be possible to ensure the sustainable development of any country.

Therefore, PELUM Ethiopia has been working with joint efforts, using different methods and practices, and doing capacity building activities to ensure that its member organizations have an integrated capacity to influence how development work should be carried out agroecologically. That is why this book focuses on the good practices and experiences of smallholder farmers, pastoral and agro-pastoral communities in the Horn of Africa with a focus in Ethiopia. On this occasion, PELUM Ethiopia Consortium would like to express its gratitude to Bread for the World for its financial support for this study and projects improving the lives of local people with a vision of Zero Hunger, which will be succeeded mainly by agroecological practices.