Stewardship towards Responsible Management of Pesticides

The case of Ethiopian Agriculture

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Cover: A smallholder cotton field in Gamo Gofa, Ethiopia.
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Abstract

This thesis examines pesticide use, practice and associated human health and environmental impacts in the Ethiopian Rift Valley. It uses participatory action research as a philosophy and methodology in order to understand the Ethiopian pesticide delivery system so as to bridge the gap amongst the main actors and create a space for dialogue. The pesticide delivery system in Ethiopia comprises policy makers, researchers, pesticide manufacturers, wholesalers, vendors, civil societies and farmers. These actors with divergent interests had been working in a dispersed manner with no concerted effort to mitigate the problem. Stewardship as a moral obligation to mitigate the problem was, therefore, introduced to the actors. The aim was to bring these actors together so as to initiate a system-wide pesticide users' stewardship network that shared a sense of responsibility at all levels to bring about an ethic of reduced and responsible use of pesticides. This was first initiated by establishing a national (meta) level multi-actor pesticide stewardship association which later triggered a regional (meso) level pesticide risk communication and local (micro) level action-oriented alternative pest management experimentation through farmer field schools. Combined methods of qualitative and quantitative data collection were used to explore the processes at all levels. The process revealed that the meta level network was viewed by all actors as a platform for collaborative learning and collective action driving institutional change at many levels. The meso level showed that even if the pesticide hazards were evident and different types of safe use training was provided, farmers' risk perception continued to be low while associated hazards remained high. This was, therefore, attributed to lack of proper risk communication, which requires reframing of the approach that promotes pesticides only as a means for agriculture productivity but gives less attention to their negative impacts. The micro level showed the field-based action as a means of participatory knowledge co-production, which has been contributing to transformation towards the overarching goal of pesticide users' stewardship. This process faced multilevel communicative, systemic, organizational and societal barriers that challenged the federal level initiative but has been well managed by the local level action, which has been a lesson for federal level actors.

Keywords: environment, Ethiopia, FFS, Human health, IPM, pesticides, risk, stewardship

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Dedication

I dedicate this book to a very good colleague and mentor in the PhD process, the late Dr. Emiru Seyoum.

Contents

List of papers

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I. TADESSE AMERA, 2016. Pesticide risk perception among farmers in the Ethiopian Rift Valley and challenges for effective risk communication. Submitted to *Njas Wageningen Journal of Life Sciences*.

II. TADESSE AMERA & NADARAJAH SRISKANDARAJAH, 2016. Innovation platforms for institutional change: the case of Pesticide Stewardship Network in the Ethiopian Rift Valley, in Aenis, T., Knierim, A., Riecher, M.-C., Ridder, R., Schobert, H. & Fischer, H. (Eds.) *Farming Systems Facing Global Challenges: Capacities and Strategies* Vol. 1, Proceedings of the 11th European IFSA Symposium, 1-4 April 2014 in Berlin, Germany, 337-349.

III. TADESSE AMERA, ROBERT MENSAH & ATALO BELAY, 2016. IPM in cotton crops in the Southern Rift Valley region of Ethiopia: Development and application of a supplementary food spray product to manage pests and beneficial insects. Under review with*International Journal of Pest Management*.

IV. TADESSE AMERA & NADARAJAH SRISKANDARAJAH, 2016. *Farmer Field Schools as a means of System-wide pesticide stewardship: the case of smallholder cotton farmers in the Ethiopian Rift Valley*. Manuscript.

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Abbreviations

ASP	Africa Stockpiles Programme
BFP	Benin Food Product
DDT	Dichlorodiphenyltrichloroethane
DLCO-EA	Desert Locust Control Organization for Eastern Africa
EFP	Ethiopian Food Product
EIAR	Ethiopian Institute for Agriculture Research
EPA	Environmental Protection Authority
EPR	Extended Producer Responsibility
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FFS	Farmer Field School
HHPs	Highly Hazardous Pesticides
IBC	Institute for Biodiversity Conservation
ICCM	International Conference on Chemicals Management
IPEN	International POPs Elimination Network
ISD	Institute for Sustainable Development
IPM	Integrated Pest Management
MOA	Ministry of Agriculture
MOH	Ministry of Health
NGOs	Non-Governmental Organizations
PAN Eth.	Pesticide Action Nexus Association Ethiopia
PAN UK	Pesticide Action Network UK
PDS	Pesticide Delivery System
POPs	Persistent Organic Pollutants
PSA	Pesticide Stewardship Association
SAICM	Strategic Approach to International Chemicals Management
UNEP	United Nations Environmental Program
USAID	United States Agency for International Development

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1 Preface

On a rainy day in August 2005, I received a call from the director of the Institute for Sustainable Development (ISD) enquiring whether I would be interested in taking on the task of coordinating the Ethiopian environmental NGOs and involving them in the Ethiopian government's endeavor to rid Ethiopia of the accumulated obsolete pesticides under the Africa Stockpiles Program (ASP). The ASP at that time was trying to rid Africa of its estimated 50,000 tons of obsolete pesticides accumulated over 40 years as well as tens of thousands of tons of contaminated soil.

As a public health professional, my experience until that time spanned over areas such as immunization, water, sanitation and hygiene, prevention of malaria through different vector control techniques, information, education and communication on communicable diseases including HIV/AIDS and general environmental health activities.

As the telephone conversation continued, my mind was contemplating my past experience and I was asking myself if I could contribute to the proposed task. I then recalled what one of my professors in my MPH class had said: "*Public health is a bridge between clinical medicine and social sciences*", and immediately on recalling this, I replied that I was willing to take the position.

The Ethiopian NGO network for ASP was, therefore, established in September 2005, and assisted the Ethiopian government in reaching the grassroots farmers and building their knowledge on how to handle, store and use pesticides. Moreover, the network tried to assess the actual pesticide problems in Ethiopia and proposed the importance of Integrated Pest Management (IPM) as one means of prevention of future accumulation of pesticides, while at the same time preventing the human health impacts they had been causing. Following this, the Ministry of Agriculture and the United Nations Food and Agriculture Organization (FAO) started cotton IPM in Gamo Gofa zone in 2006, which was also followed by ISD and the NGO network.

As the network continued contributing to this process, the pesticide problems were not limited to the need for the disposal of obsolete ones and prevention of future accumulation. Rather, the problems were more complicated and needed more attention. Through the course of the task, it was revealed that pesticides were not being properly stored, personal protective equipment was not being used, pesticide containers were being used to contain foodstuffs and moreover, pesticide hazards were not topics of discussion. Assessing this situation on the ground, members of the NGO network decided to formalize this network to enable it to work beyond the ASP activities, which resulted in the establishment of the Pesticide Action Nexus Association (PAN-Ethiopia) in 2007, which was formally registered by the ministry of justice of Ethiopia in 2008. I was also nominated as the director of PAN-Ethiopia and have been leading the organization since then.

In 2009, the ministry of agriculture of Ethiopia, and the Desert Locust Control Organization for Eastern Africa in collaboration with the United States Agency for International Development (USAID) involved ISD and PAN-Ethiopia in a newly-initiated dialogue forum that started discussing how each actor in the pesticide delivery system of Ethiopia could contribute towards mitigating the impacts of pesticides on human health and the environment. This discussion resulted in the consensus of all actors to work with the notion of "*pesticide users' stewardship*". This new situation opened a door for me to pursue a PhD study as a way of engaging myself more in the grassroots level change process while also allowing me to step back and undertake some reflection on the process.

As I began my study, I realized that the agriculture sector was more complex than I had previously imagined. It is one of the main pillars for our survival yet it is also a major sector that threatens our very existence. As a way of showing how we should look at the agriculture sector, in his 2016 speech at the European Union forum for the future of agriculture, Mr. Achim Steiner, the Executive Director of the United Nations Environmental Program (UNEP) put across these paradoxes as follows:

> […] agriculture probably highlights more than most the way in which our fates are inextricably linked and the hard questions that must be asked: a third of the world's economically active labour force works in agriculture, which uses 70 per cent of water and antibiotics, while accounting for 70 per cent of biodiversity loss; a third of the world's arable land has been lost to erosion in the last 40 years, just as the number of people to be fed from that land almost doubled and as land degradation and desertification are being made worse by climate change and poor management of agricultural exports; a third of the world's food is never actually eaten, so although we produce enough for the entire population to be

> adequately fed, 800 million people are chronically undernourished and nearly half of all infant deaths are due to hunger, while two billion people are overweight and 600 million obese. Which is a cruel irony, given that ending hunger by 2025 requires an additional $44 billion per year, yet we're losing production and ecosystem services worth $40 billion a year. And all of that is even before you start to consider the contribution of waste, emissions or chemicals from the fertilization, packaging, transportation and disposal of agriculture products can make to the nine million deaths a year related to air, ground and water pollution […].[1] (Mr. Achim Steiner, 2016)

In the process of my study I pick a single thread, "Pesticide users' stewardship", from the above complex situation and I try to look at it through the lens of environmental communication.

[1] A Mountain of Opportunity - Speech by UNEP Executive Director Achim Steiner at the Forum for the Future of Agriculture http://www.unep.org/newscentre/Default.aspx?DocumentID=27069&ArticleID=36105&l=en

2 Introduction

Smallholder farmers are the major actors in Ethiopian agriculture and are responsible for the lion's share of crops produced every year. In 2010, the country produced 22.5 million tons of crops, of which 95 percent were from smallholder farmers and the remainder from commercial farms (MoA, 2012). This indicates that it is important to provide significant support to smallholder farmers so as to increase production and productivity in the agriculture sector.

Smallholder farmers use different external inputs, including pesticides, to grow subsistence and commercial crops of different varieties. However, it has also been common for them to have been affected by pesticides and to have applied them without monitoring their crop fields for economic pests, taking action to control economic pests often after the crops had sustained significant damage and they had not received significant support while they were trying to manage regular pests. This has been creating crises in the management of pests that are mainly due to the inability of the pest management service to respond to the needs of the farmers. The situation of the pest management service in Ethiopia remained inadequately defined and poorly understood, as is the case in most African countries. The more holistic/systemic approach, comprising all plant protection issues, has been preferred as opposed to a unidisciplinary or even a single sector-oriented way of handling pest aspects separately, which had been more common in the pest management service of the country.

Pest management services have been trying to help farmers to reduce pest-related economic losses in their produce. The pest management service was started by the government of Ethiopia in the 1940s with a focus on the desert locust, which was causing significant economic damage to the vegetation in the country. This service was further improved upon and expanded to include other pests identified at the time as causing economic damage to different crops. The service included pest identification, technical training and advice on how to manage pests and provision of inputs to apply pesticides. In 1956, a group of permanent locust control staff was organized and independently established with a budget and equipment; and an armyworm survey and some control actions were started. A permanent plant protection section within the Ministry of Agriculture was also established to handle the study of pest problems, demonstration of modern equipment and pesticides, training personnel and performing import, export and domestic plant quarantines (MoA, 2011). Moreover, basic plant pest laws under which the Ministry of Agriculture could carry out control programs and operate and enforce plant quarantine regulations were developed.

However, the use of chemical pesticides against crop pests corresponds with the development of commercial farms in the early 1960s. They were introduced to smallholder farmers following the implementation of comprehensive integrated package projects including the Chilalo Agricultural Development Unit (CADU, 1967), the Wolaita Agricultural Development Unit (WADU, 1970), the Minimum Package Project (MPP, 1971) under the Extension and Project Implementation Department (EPID) by the Ministry of Agriculture.

The plant protection section in the Ministry of Agriculture was further strengthened by lifting it up to a division level before the 1970s. In 1972, a Crop Protection and Regulatory Division was established within the MoA and plant protection activities were started in a more organized manner. As a result, the control of migratory and outbreak pests was given more emphasis and pesticide use and sales were widely introduced to the farmers. The overall responsibility of the control of pests and plant diseases, the monitoring and control of migratory pests as well as epidemic outbreaks of non-migratory pests and plant diseases was the direct responsibility of this division, whereas the routine control of regular pests was made the direct responsibility of the farmers and farmers' cooperatives and associations (MoA, 2011). The division was mandated to give guidance on regular pests and support to farmers through the routine extension service and elaboration and testing of preventive and control procedures. National plant protection laboratories were established in 1977 with the objective of providing proper plant protection services. The division's structure was raised to department level in the mid-1980s; however the capacity of the national plant protection service was limited by inadequately equipped laboratory services and lack of trained human power. As a result of this, further institution-building activities were carried out between 1987 and 1992 (MoA, 2011).

In 1987, the crop protection and regulatory department was divided into crop protection and plant quarantine divisions. The crop protection division was in turn subdivided into 7 units: entomology, plant pathology, weeds, birds and rodents, pesticide chemistry, pesticide application, and storage problems.

At that time the crop protection division had 7 plant health offices in different regions of the country. It also had scouts and agents at regional, zonal and district levels. Agents at the district level were responsible for training farmer brigades, whereas those at the zonal level were mostly involved in control efforts through provision of motorized knapsack sprayers, fuel and pesticides.

The plant quarantine division had units for handling policy and regulations on the import and export of plant materials, operations, and technical aspects of quarantine. In 1992, the crop protection and regulatory department was rated as a competent institution with respect to pest and disease identification and monitoring, extension and training (MoA, 2011). After 1992, the crop protection and regulatory department underwent reorganization and was merged with the crop production department to form the crop production and protection technologies and regulatory department. Crop protection was organized at division level and had three teams working under it: the crop protection team, the crop protection laboratories and quarantine team and the pesticides registration team.

The Ministry of Agriculture was again reorganized in 2004, and crop protection was separated from production and set under a newly- formed structure named the crop protection directorate. The mandate of the directorate was revised to include all measures necessary to conduct quarantine controls on plants and seeds and prevent outbreaks of plant diseases and pests. This period (2005-2010) corresponded with the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (MoA, 2006).

In 2008, there was a total shift in the thinking and direction of the Ministry of Agriculture on how to provide pest management services in the country at large. In line with this, the crop protection and regulatory directorate was subdivided and the pesticides registration and control, migratory pest control and pest regulatory components were maintained within the Animal and Plant Health Regulatory Directorate. Additionally, the pest management service, which was intended to manage regular pests, was significantly reduced and transferred to the extension directorate. Following this arrangement and due to the generalist concept of “one will do it all” that was being promoted in the government’s Business Plan Reengineering (BPR) process, the major disciplines in crop protection that were formerly handled by different experts (entomologists, plant pathologists, weed scientists, vertebrate pest control experts, pesticide application experts) were removed from the structure and all the responsibilities of dealing with these different aspects were given to a single expert to handle. This arrangement was adopted by all the regions, zones and districts across the country. The pest management service that was split between the animal and plant health regulatory directorate and the extension directorates was found to be a barrier to the provision of effective service to farmers. It is currently under discussion whether or not the plant health regulatory directorate and the extension service directorate should be strengthened for the provision of pest management services in a coordinated manner. The point is that the extension directorate should receive all the necessary technical backstopping in plant protection from the plant health regulatory directorate while providing training to experts on major economic crop production packages; whereas the crop protection directorate would provide all support in the management of migratory and regular pests.

According to the experts in the Ministry of Agriculture and concerned professionals from universities and other organizations, the capacity of the Ministry of Agriculture is not at a sufficient level to meet the demand of the vast majority of smallholder farmers. In an assessment of the areas of correction during a workshop hosted by the Ministry of Agriculture of Ethiopia in 2015, the experts identified the following critical problems:

- Policies and regulations outdated, not enforced or absent
- Plant Protection Laboratories non-functional or poorly equipped
- Pest focused biosystematics not organized or inadequate
- Capacity and coordination/linkage of pest management service poorly developed
- Poor awareness of pest management policies, legal provisions and practices
- Clearly undefined mandate and system in pest management service
- Poor phytosanitary services and low focus on invasive alien species
- Information communication technologies are least in use in pest management service
- Misuse/abuse of pesticides and lack of tracking mechanism
- Limited experience in IPM promotion

This problem has also been appreciated by MoA and DLCO-EA together with USAID since 2009, which resulted in the establishment of a meta level national action-oriented, policy-directed pesticide stewardship network of all actors which joined to work on institutionalising the idea of an ethical approach to mitigate human health and the environmental impacts of pesticides. This national (meta) level of action facilitated the policy dialogue among actors in the pesticide delivery system. A regional (meso level) process on pesticide risk communication and a local (micro) level action IPM-FFS took place in the Ethiopian Rift Valley, where large amounts of pesticide have been used for vegetable and cotton production.

This thesis is based on the national (meta) level of policy dialogue processes, regional (meso) level of appreciating the depth of pesticide-related problems and the local (micro) level of grassroots based action and reflection incorporated in the four papers below:

I. *Pesticide risk perception among farmers in the Ethiopian Rift Valley and challenges for effective risk communication*

II. *Innovation platforms for institutional change: the case of Pesticide Stewardship Network in the Ethiopian Rift Valley*

III. *IPM in cotton crops in the Southern Rift Valley region of Ethiopia: Development and application of a supplementary food spray product to manage pests and beneficial insects*

IV. *Farmer Field Schools as a means of System-wide pesticide stewardship: the case of smallholder cotton farmers in the Ethiopian Rift Valley*

3 Background

Challenges in agriculture, especially the loss of crops due to insects, weeds and diseases, coupled with the need for the requirement for high production to feed the ever-growing population provided justification for agricultural modernization. There has been evidence showing the importance of agricultural modernization and the use of pesticides and biotechnologies in the economic development and public health sector. There have also been reports showing good results in crop protection and agricultural production as well as improvement in public health (Benbrook, 2001; O'Shaughnessy, 2008). Agricultural modernization, however, is not sufficient on its own to handle the challenge. It rather continues to implement one approach that results in short-term good results for a decade or two and shifts to another approach which may not have a long -lasting solution for the problem facing the agriculture sector. Thus, agricultural modernization continued to engage itself with a dynamic process of applying new technologies, facing newer challenges and coming up with newer solutions that may yet lead to further challenges to the extent of unknowability of what they may bring to humanity. Ethiopia, as a developing nation whose economy is mainly based on agriculture, has also been sharing the benefits and challenges of this process.

3.1 Historical dimensions of agricultural modernization

The development of agricultural modernization and its challenges can be seen from three historical dimensions i) the agriculture treadmill ii) the pesticide treadmill and iii) the ongoing debate on genetic modification. All three dimensions are presented in the following sections.

3.1.1 The agriculture treadmill

Agriculture modernization encouraged a large number of farmers to produce the same commodity as per the market requirement until a flaw in the system was clearly articulated by Cochrane (1958) as the “agriculture treadmill” (Cochrane, 1958). The first occurrence of the agriculture treadmill was evident as a "product price" treadmill (Levins and Cochrane, 1996). According to Cochrane (1958), farmers adopt new technologies to increase their incomes in which “early adopters” make profits for a short while because of their lower unit production costs. When more farmers start adopting the technology, production goes up, prices go down and profits are no longer possible, even with the lower production costs. This forces average farmers to adopt the technology and lower their production costs in order to survive. The farmers who refuse to adopt new technology (laggards) cannot compete with the lower product price and are forced to leave the sector to those who have succeeded in expanding. The price of land becomes high, and can only be afforded by a few successful farmers which allows them to adopt more technologies, maintain high production and a stable market.

However, the experience of Ecuadorian farmers with the agriculture treadmill, according to Sherwood (2009), is different from Cochrane’s (1958) link with product price and land price. Farmers in Carchi were affected by the unstable price of potatoes due to the unpredictability of supply. This was a result of the combination of the highly variable mountain environment and climate, environmental and ecological disturbances associated with agricultural modernization leading to new pest problems and soil degradation which was also aggravated by the withdrawal of public support for research and extension as well as credit, leaving agricultural support in the hands of private industry. It was also related to the externalization of human health and the environmental costs of external input of the market-oriented production, which caused many to go into debt and abandon agriculture (Sherwood, 2009).

3.1.2 The pesticide treadmill

The continuing dilemma with pesticides is that they opened up many possibilities for improving agriculture and public health on one hand but they closed other doors by creating extreme dependence on them. The increase of productivity with the application of pesticides was unable to function as a sustainable pest management system on which to predictably depend. Most of the negative impacts of pesticides on human health and the environment and the unintended consequences they brought begin to be reported more after Rachel Carson’s book “Silent Spring”, which was published in 1962 (Carson, 2002). One of the notable stories about the early years of the pesticide treadmill was reported as “operation cat drop” from the unintended impacts in indoor application of DDT in malaria control in the 1950s. The story had many versions but the one which is widely shared in scientific journals and books read as follows:

> In the early 1950s, there was an outbreak of a serious disease called malaria among the Dayak people in Borneo. The World Health Organization tried to solve the problem. They sprayed large amounts of a chemical called DDT to kill the mosquitoes that carried the malaria. The mosquitoes died and there was less malaria. That was good. However, there were side effects. One of the first effects was that the roofs of people’s houses began to fall down on their heads. It turned out that the DDT was also killing a parasitic wasp that ate thatch-eating caterpillars. Without the wasps to eat them, there were more and more thatch-eating caterpillars. Worse than that, the insects that died from being poisoned by DDT were eaten by gecko lizards, which were then eaten by cats. The cats started to die, the rats flourished, and the people were threatened by outbreaks of two new serious diseases carried by the rats, sylvatic plague and typhus. To cope with these problems, which it had itself created, the World Health Organization had to parachute live cats into Borneo (O'Shaughnessy, 2008).

The different versions of this story attempted to explain different routes of exposure to cats and whether chemicals other than DDT were also involved. However, all stories agreed that when DDT was applied, the incidence of malaria decreased, thatch roofs fell, cats died, rats flourished, and new diseases emerged. This is a classic example of bio accumulation and bio magnification that rises up in the food chain and creates more damage.

The agriculture sector has also been the victim of the consequences of pesticides. Pesticides disrupt the balance of pests and predators so that once-harmless species grow sufficiently numerous to become pests. The use of wide spectrum pesticides disrupts natural mechanisms of pest management leading to the proliferation of more pests and diseases, including the emergence of secondary pests that would cause more trouble than the pests the chemicals were originally designed to control (Dover, 1985; Poswal and Williamson, 1998; Sherwood, 2009) which is also coined by van den Bosch (1977) as the “pesticide treadmill” (Van Den Bosch, 1977).

The environmental and human health effects of agricultural modernization (Pretty et al., 2001) include (1) pesticides contaminating water and harming wildlife and human health; (2) nitrate and phosphate from fertilizers, livestock wastes and silage effluents contaminating water, and so contributing to algal blooms, deoxygenation, fish deaths and nuisance to leisure users; (3) soil erosion disrupting watercourses, and run-off from eroded land causing flooding and damage to housing and natural resources; (4) harm to consumers exposed to harmful residues and micro-organisms in foods; and (5) contamination of the atmospheric environment by methane, nitrous oxide and ammonia derived from livestock, their manure and fertilizers (Altieri, 1995; Conway and Pretty, 1991; Pretty, 1999; Pretty, 1995; Sherwood, 2009).

3.1.3 Genetic modification

After much evidence supporting the limitations of pesticides, the continuation of the decline in productivity and the creation of chemical dependence, another version of agricultural modernization, biotechnology, appeared with the application of genetic engineering to develop transgenic crops. It promised to increase world agricultural productivity, enhance food security, and move agriculture away from dependence on chemical inputs, therefore helping to reduce environmental problems. However, others argued that 1) hunger is due to a gap between food production and human population growth; 2) many bio-engineered crops are not designed to increase yields for poor small farmers, so that they may not benefit from them. It is also argued that genetically modified crops are mostly grown for export by big farmers, not for local consumption. In some cases they are used as animal feed to produce meat consumed mostly by the wealthy; 3) transgenic crops pose serious environmental risks, continuously underplayed by the biotechnology industry and 4) agro-ecological alternatives are competent to solve the stated problems (Watts and Williamson, 2015) in a socially equitable manner and in a more environmentally harmonious way (Altieri and Rosset, 2002). Research has also shown that fewer herbicide active ingredients are applied on the average acre of Roundup-Ready soybeans relative to the average conventional acre; but more pounds of herbicide is applied on the average acre of Roundup-Ready soybeans compared to the average acre planted with conventional soybean varieties; and herbicide use on Roundup-Ready soybean acres is gradually rising as a result of weed shifts, late-season weed escapes leading to a buildup in weed seed banks, and loss of susceptibility to glyphosate in certain weed species (Benbrook, 2001). The growth of the agrochemical industry and the support it receives from governments led to a continuation of agricultural intensification through further "technology adoption" and "market integration". Its social impacts led to a reduction in the number of farms, and an increase in the size of those farms, bringing about a decline in the number of people employed in agriculture that resulted in rural poverty (Nicholls and Altieri, 1997; Pretty, 1999; Pretty et al., 2001). Smallholder farmers that struggle to overcome the rising costs of cultivation take on more debts. However, this does not guarantee better weather conditions, high productivity and a better market. By the time unintended shocks result in crop failure, farmers have committed suicide, as is the case in many parts of India (Gill and Singh, 2006; Mohanty, 2005; Sridhar, 2006; Stone, 2002; Vasavi, 2009).

The context of Ethiopia

Ethiopia's current development agenda is guided by two key strategies: the Growth and Transformation Plan (GTP) and the Climate Resilient Green Economy (CRGE) strategy. The main goal of the GTP is to "extricate Ethiopia from poverty to reach the level of a middle-income economy by 2025." To achieve the GTP goal, the Government of Ethiopia has prioritized key sectors such as agriculture and industry as drivers to promote sustained economic growth and job creation. With a considerable portion of its population experiencing chronic food insecurity, Ethiopia is striving to enhance agricultural production and productivity with a view to comprehensively tackling widespread poverty and addressing the major national issue of food insecurity. Fuelled by the growth drive, the use of agro-chemicals is on the increase. Even though more training has been provided by MoA and Crop Life International on the "safe" use of pesticides, there is still a low level of responsible pesticide management knowledge and practice by a large proportion of the smallholder farming community. The use of pesticides driven by the national desire for accelerated economic growth, orientation to international trade and poverty alleviation is, therefore, on an increasing trend. This is, however, not supported by strategies on how to mitigate the effects on human health and the environmental impacts of pesticides.

The need to feed the ever-increasing population of Ethiopia and the interest in producing an exportable volume of products to access the global markets entailed an ever-increasing pressure to intensify agriculture and increase the use of chemical pesticides. The negative impacts associated with the use of hazardous chemicals and pesticide residues in Ethiopia have been more recognized only in the last 10 years. Improper management of pesticides in the country includes among others improper selection, over-application, fallacy at the time of application, non-targeted application, lack of monitoring of pesticide use and efficacy, poor storage practices and improper disposal of the obsolete remains. The poor management of pesticides is likely to affect crop production, and to pose unacceptable risks to humans and the environment. The process of intensifying agriculture should take care to minimize losses and environmental risks in Ethiopia, or else any benefit will be short term and fail to meet the needs of the population in a sustainable manner.

Despite all the efforts being made to adopt an Integrated Pest Management (IPM) system in the country, such technology was not able to be spread to as many areas and crops as anticipated due to lack of strong policy support, and the agricultural sector is still characterized by rather low productivity and quality. One of the reasons for low productivity and quality is due to the low level of applying appropriate pest management techniques. Certain substandard and hazardous pesticides are illegally circulating in the country. For instance, pesticide contamination resulting from misuse of pesticides in some agricultural crops of high export value such as coffee was reported in 2008, resulting in rejection by the importing country and warranting residue analysis.

Although there is legislation governing pesticide registration and guidelines on their importation and testing, the appropriate use and management of pesticides has not been enforced effectively. There has been a slow national process of banning pesticides that had previously been banned internationally. For instance DDT, which is one of the banned pesticides in forty-nine countries worldwide and in many African countries, had been in use in Ethiopia until 2011 for the control of malaria-carrying mosquitoes by the Ministry of Health (MoH); and has been reported to have been illegally diverted to agricultural pest control in certain areas (Amera and Abate, 2008).

In order to deal with the pesticide situation in Ethiopia, it is important to know the formal regulatory and institutional arrangements in place. The following section illustrates the national and international policy frameworks and institutional arrangements in relation to pesticide management in Ethiopia.

3.2 Existing Policies, Legal and Regulatory Mechanisms

Ethiopia has developed policies and legal instruments towards production and use of pesticides and has also accepted and ratified different international conventions and agreements. The legislative framework in the country is often institutionalized for instrumental action. Once an institution is set up, it is mandated to initiate relevant legislation for its operation. The main policy frameworks and legal instruments in Ethiopia are:

Proclamation of the Ethiopian Constitution

(Proclamation No.1/1995), in which under article 43 among others, people's right to a clean and healthy environment and proper compensation provisions are indicated (FDRE, 1995).

The Environmental Policy of Ethiopia (1997)

This calls among other things for the prevention of pollution while sector environmental policies relating to soil husbandry and sustainable agriculture emphasize the use of biological and cultural pest control approaches and safeguarding of environmental health by adequately regulating agricultural chemicals (Ethiopian-EPA, 1997).

Pesticide Registration and Control Proclamation (No. 674/2010)

This proclamation was issued in accordance with Article 55 and sub-article 1 of the Ethiopian constitution. This proclamation is aimed at laying down a scheme of control that would minimize the adverse effects that pesticide use might cause to humans, animals and the environment and recognizing the need to enact comprehensive legislation to regulate the manufacture, formulation, import, export storage, distribution sale, use and disposal of pesticides (FDRE, 2010).

Draft pesticide registration and control regulation

The legal instrument supporting the above proclamation has been prepared in order to bring the regulation more in line with the enacted pesticide proclamation and internationally agreed pesticide registration procedures. It sets requirements, criteria and guidelines for public health and environmental toxicological data that are critical to the decision making process of the registration of pesticides. Moreover, great emphasis has been given to the regulation being transparent and showing clear objectivity when dealing with matters of pesticide registration, import and export, competence assurance certificate licensing, packaging, storage, transportation, packaging, efficacy, labeling, use and quality control. The document covers all elements of pesticide management. However, even though it was claimed that the draft regulatory framework for the implementation and enforcement of the above proclamation had been finalized, the delay of approval by the council of ministers has left the proclamation without any regulatory support for the last six years.

Ethiopian Organic Agriculture System Proclamation (No. 488/2006)

This proclamation has been made in accordance with Article 55 (1) of the Ethiopian constitution. The proclamation has been issued in response to the increased international demand for organically produced (without the use of synthetic chemicals) foodstuffs and products (FDRE, 2006).

Environmental Impact Assessment (EIA) Proclamation (No. 299/2002)

This is a practicable proclamation that makes an Environmental Impact Assessment (EIA) an absolute requirement for all investments by the government as well as private investors. Studies and EIAs, according to the proclamation, should be submitted to the Ministry of Environment and Forest for approval before the issuance of investment permits (FDRE, 2002b).

Environmental Pollution Control Proclamation (No. 300/2002)
This proclamation aims at eliminating, or at least mitigating pollution, requiring among other things control of pollution, management of hazardous waste, environmental protection and punitive and incentive measures (FDRE, 2002a).

Commercial Registration and Business Licensing Proclamation (No. 67/1997)
This proclamation is aimed at restricting illegal commercial activities through the provision of a law on registration and licensing. The Ministry of Trade and Industry (MoTI) is the authority responsible for regulating imports and setting up businesses (FDRE, 1997).

3.3 Links to International Conventions and Processes on Pesticide Management

The recommendations of the 1992 Earth Summit (UN Conference on Environment and Development) and the adoption of Agenda 21 on sustainable development by heads of state have led to various processes at international as well as national levels. Particularly, Chapter 19 of the Agenda deals with environmentally-sound management of pesticides as well as illegal trafficking of hazardous products. The attainment of sound chemical management by the year 2000 was one of the agreed-upon goals at the conference.

Under the auspices of the then Environmental Protection Authority (now Ministry of Environment and Forest), the Ethiopian national chemical profile was prepared in 1999. Ethiopia was one of the countries that prepared a national chemical management profile following the recommendations of the Intergovernmental Forum on Chemical Safety (IFCS) and the Strategic Approach to International Chemical Management (SAICM), which was adopted by the International Chemical Conference in 2006 in Dubai. The global plan of action, one of the SAICM documents, specifies a variety of work areas including pesticide management; sound agricultural practices; highly hazardous pesticides (HHPs), risk management and reduction; legal, policy institutional aspects; risk assessment, management and communication; waste management; and capacity building to national actions. Ethiopia has, therefore, taken some steps through signing and ratifying the following major conventions:

- Rotterdam Convention on Prior Informed Consent (PIC), ratified in 2002 by means of Proclamation No. 278/2002.

The Rotterdam Convention, which deals with the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade, is an international treaty promoting shared responsibility between exporting and importing countries in protecting human health and the environment from certain banned or restricted hazardous chemicals and pesticides, and providing a mechanism for the exchange of information about potentially hazardous chemicals.

- Stockholm Convention on Persistent Organic Pollutants (POPs), ratified in 2002 by means of Proclamation No.356/2002

The Stockholm Convention on persistent organic pollutants is an international treaty to protect human health and the environment from the harmful effects of POPs. More than 170 countries have ratified the convention. The convention requires that parties to the convention take measures to eliminate or restrict the production and use of certain hazardous chemicals on the list of POPs in the convention.

Following the signing of the Stockholm Convention on POPs in May 2002, and ratification of the instrument in July 2002, Ethiopia prepared a National Implementation Plan (NIP) to meet the national obligations under the Convention. Activities such as training and creation of awareness of POPs were carried out, as well as the preparation of a preliminary inventory. National POPs priorities were set and key issues were identified, human and institutional capacity were strengthened for the management of POPS, and an attempt was made to develop the capacity and capability to identify, analyze, research and monitor POPS. The then Environmental Protection Authority (EPA) was authorized to take actions in cooperation with the appropriate federal, regional and city government organs to implement most of the conventions. However, the revision and implementation of NIPs as well as taking appropriate measures towards the realization of the convention has not made progress to the desired degree due to lack of resources and technical capability.

- The Basel Convention on the trans-boundary movement of hazardous wastes and their disposal entered into force in September 1992.

This international treaty is designed to reduce movement of hazardous waste between nations, specifically from developed to least developed countries (LDCs). However, the convention does not include radioactive waste. It aims for sound management of waste as close as possible to the sources of generation and assisting LDCs in environmentally sound management of hazardous waste.

- The Bamako Convention deals with the ban of the import into Africa and the control of trans-boundary movement and management of hazardous waste within Africa: ratified in 2002 by means of Proclamation No. 355/2002.

This convention is the African version of the Basel convention, and regulates the trans-boundary movement of hazardous wastes within Africa itself.

- The Strategic Approach to International Chemicals Management (SAICM), which is a voluntary instrument adopted by governments in 2006 in Dubai (UNEP, 2006).

The Strategic Approach to International Chemicals Management (SAICM) is a policy framework to promote chemical safety around the world. The overall objective of SAICM is to achieve the sound management of chemicals throughout their life cycle so that, by 2020, chemicals are produced and used in ways that minimize significant adverse impacts on human health and the environment. Unlike other conventions, SAICM does not restrict or ban specific types of hazardous chemicals. It is a platform for national authorities to exchange information on chemical management policies for the purpose of achieving the sound management of chemicals throughout their life cycle.

- The Minamata Convention on Mercury, signed by governments in October 2013 in Kumamoto, Japan and pending ratification by signatory nations.

The Minamata Convention on Mercury is a global treaty to protect human health and the environment from the adverse effects of mercury and its compounds. The major highlights of the Minamata Convention on Mercury include a ban on new mercury mines, the phasing-out of existing mines and mercury-added products, as well as control measures on air emissions (UNEP, 2013).

- International Code of Conduct on the Distribution and Use of Pesticides

The International Code of Conduct on the Distribution and Use of Pesticides was one of the first voluntary codes of conduct in support of increased food security, while at the same time protecting human health and the environment. It was adopted in 1985 by the FAO Conference at its Twenty-third Session (FAO, 1985), and was subsequently amended to include provisions for the Prior Informed Consent (PIC) procedure at the Twenty-fifth Session of the FAO Conference in 1989. The Code established voluntary standards of conduct for all public and private entities engaged in, or associated with, the distribution and use of pesticides, and its adoption has served as the globally accepted standard for pesticide management.

Policy level engagement

In my capacity as a national NGO director and as a member of international networks, I have been engaged in national and international policy dialogues prior to and during this PhD study, as well as currently.

Nationally, I have been engaged in different policy dialogues on pesticide management, plant protection, pesticide risk reduction, IPM, organic agriculture and other chemical-related issues.

Internationally, I have served as a steering committee member of the International POPs Elimination Network (IPEN), which is an umbrella organization of about 700 NGOs in more than 100 countries globally; and which works for a toxic free future. My engagement in the international policy and action arena has been significant in terms of relating national and local level action to the international discourse. I did not draw data or information from the national and international dialogues for this thesis. However, it is an important backdrop for readers. Table 1 presents major international pesticide-related events with which I have been engaged.

Table 1. International policy dialogue engagement of the author

International event	Place and year of event	Role of the author
The 8th Conference of Parties (COP8) of the Basel Convention on transboundary movement of hazardous wastes	December 2006-Nairobi, Kenya	As an observer representing Ethiopian civil society organizations, reflected on the Ethiopian case.
Africa Stockpiles Program (ASP) NGOs forum	April 2007-Rabat, Morocco	As a member, presented the obsolete pesticide disposal progress of Ethiopia and its challenges. The meeting was attended by civil society representatives from Eritrea, Ethiopia, Mali, Mozambique, Nigeria, Senegal, South Africa and Tanzania.
Africa Stockpiles Program (ASP) stakeholders forum	October 2007-Rabat, Morocco	As a stakeholder, presented the obsolete pesticide disposal progress of Ethiopia, contribution of civil society in the process and its challenges. It was attended by civil society and government representatives from the above-mentioned countries and donor organizations including FAO and the World Bank.

International event	Place and year of event	Role of the author
25th anniversary of PAN-International and global pesticide risk reduction planning meeting	December, 2007- Penang and Kuala Lumpur, Malaysia	As a member, presented the Ethiopian pesticide management situation and created links to multiple international networks.
Conference of the African Network for Chemical Analysis of Pesticides (ANCAP)	November 2008- Wad Madani, Sudan	As an invited professional, presented a paper on pesticide use practices of smallholders in Ethiopia.
5th World Urban Forum	March 2010-Rio de Janeiro, Brazil	As an invited guest, presented the urban environmental challenges of Ethiopia.
5th Conference of Parties (COP5) of the Stockholm Convention	April 2011- Geneva Switzerland	As an observer, contributed in highly hazardous pesticides phase-out working group and made interventions on different chemical issues.
3rd International Conference on Chemicals Management	September 2011- Nairobi, Kenya	As a stakeholder, contributed in highly hazardous pesticides phase-out working group and made interventions on different chemical issues.
5th Joint Meeting on Pesticide Management (JMPM) of the Panel of Experts of WHO and FAO	October 2011- Rome, Italy	As an observer, presented the importance of conceptualizing pesticide users' stewardship in the revision process of the FAO code of conduct on the distribution and use of pesticides.
World Summit for Sustainable Development (Rio+20)	June 2012- Rio de Janeiro, Brazil	As major groups' stakeholder, presented the Ethiopian situation to the preparatory meeting on chemicals and waste working group of the toxic free future team.
Conference of Plenipotentiaries on the Minamata Convention on Mercury	October 2013- Minamata & Kumamoto, Japan	As an observer, engaged at the civil societies' preparatory meeting with the Minamata victims in Minamata and participated in the main convention discussion in Kumamoto, Japan.
Extra-ordinary Conference of Parties (EXCoP) of the Basel, Rotterdam and Stockholm Conventions	April 2013 and April 2015- both in Geneva, Switzerland	As an observer, contributed to a book entitled *Introduction to endocrine disrupting chemicals* which was distributed during these meetings and made interventions on different chemical convention issues.
4th session of the International Conference on Chemicals Management (ICCM4)	October 2015- Geneva, Switzerland	As a panelist at the High Level Segment Panel on *The SAICM Model In Action*, I presented part of the IPM-FFS results and the need for pesticide users' stewardship as one means of mitigating pesticide hazards.
PAN-International strategy and planning committee meeting	January 2016- Honolulu, Hawai'i; USA	As a member, engaged in the strategy development of PAN-International's pesticide risk reduction activities over the next few years and was involved in different working groups.
The 2nd meeting of United Nations Environment Assembly	May 2016- Nairobi, Kenya	As a major groups' stakeholder, engaged in the work of the chemicals and waste cluster working group.

3.4 Institutions Involved in the Management of Pesticides

The Ministry of Agriculture (MoA), through the Animal and Plant Health Regulatory Directorate (APHRD), is the lead institute in pesticide management with responsibility for registration of pesticides, post-registration management as well as regulation and control. Under proclamation 674/2010, all pesticides have to be registered by a pesticide registration team before importation. The team approves registration of pesticides after receiving evaluation reports from the pesticide technical committee. The registration procedure also involves acceptance of applications and dossier evaluation for registration by the MoA. Technical efficacy tests are carried out by the Ethiopian Institute for Agriculture Research (EIAR) and universities who send their reports and recommendations directly to the MoA for decisions. The EIAR is the lead research institute dealing with field efficacy tests.

The Ministry of Environment and Forest (the then Environmental Protection Authority - EPA) is the national umbrella organization with responsibilities regarding Environmental Impact aspects of pesticides as well as development and implementation of national implementation plans towards the realization of international conventions and agreements that the country has signed and approved. The Ministry is also authorized to have an input in the issuance of investment licenses together with the Ministry of Trade and Industry.

The Ministry of Health (MoH) is the main importer and distributor of public health pesticides for vector control, including DDT before its total ban in Ethiopia in 2011. The order of chemicals by the MoH is channelled to the Adami Tulu pesticide formulation plant located in the central Ethiopian Rift Valley area which usually accommodates demand by delivering to the Ministry as required.

The Ministry of Trade and Industry (MoTI) issues licenses for importers, retailers and manufacturers of pesticides based on certificates of competence presented by the MoA.

The Ministry of Labour and Social Affairs (MoLSA) ensures that all employers create a safe work environment, keep records of incidences of injury to workers and make such records available to inspectors.

The Federal Government Customs and Revenue Authority releases imports of pesticides upon receiving certificates of clearance from the MoA and adequate inspection by inspectors. The authority also keeps import records of pesticides.

3.5 Pesticide usage in Ethiopia

Pesticide import

A report of the Ministry of Agriculture of Ethiopia indicated that the number of pesticides registered and imported to Ethiopia increased from 28 in 1996 to 274 in 2011. The report also indicated that the annual pesticide import (Table 2) in 2012 was about 32,230 tons.

Table 2. Pesticide importation into Ethiopia between 2000 and 2012 (MT)

Year	Insecticides	Herbicides	Fungicides	Others	Total (Metric tons)
2000	160.7	805.9	46.8	2.5	1015.9
2001	462.6	760.7	36.0	177.5	1436.8
2002	706.0	1136.0	71.0	171.0	2084.0
2003	359.0	868.5	77.0	323.0	1627.0
2004	407.0	915.7	114.0	322.8	1759.5
2005	455.6	1197.6	146.6	423.8	2223.7
2006	569.3	1821.1	135.7	801.6	3327.7
2007	595.7	1687.9	153.7	594.4	3031.7
2008	453.1	1634.9	141.7	212.7	2442.4
2009	376.8	3105.8	223.1	12.6	4718.3
2010	651.9	3146.8	387.3	25.4	4211.5
2011	431.0	973.0	337.0	_	1741.8
2012	1212.0	1992.0	355.0	52.0	3647.7
Total	6840.7	20045.9	2224.9	3119.3	32230.8

Source: Ministry of Agriculture of Ethiopia, 2013

Pesticide formulation in the country

In addition to importing from abroad, Ethiopia also has a pesticide formulation plant in the central Rift Valley, near the town of Adami Tulu, some 165 km south of Addis Ababa. During the first five to six years after its establishment in 1995, it produced eight insecticide products for smallholder farmers and commercial cotton farms. The enterprise was converted to a share company in 2000 and is currently engaged in the processing and marketing of twenty-two types of pesticides, about fifty percent of which are insecticides for use in crop production (Table 3). A few of the pesticides, including DDT, were being produced by the Company for the Ministry of Health on request. However, according to the information from the Company (Table 2), work on processing and marketing of DDT for the Ministry of Health was terminated as of 2011.

Table 3. Pesticide Production for Agriculture and Public Health by Adami Tulu Pesticide Processing Share Company during 2000 - 2012 (in Metric Tons)

Year	Insecticides for		Acaricides	Fungicides	Total (Metric ton)
	Agriculture	Public Health			
2000	106.46	-	2.50	-	108.96
2001	293.75	93.65	3.03	-	390.43
2002	319.71	60.34	2.00	-	382.05
2003	545.50	157.78	7.42	-	710.70
2004	397.17	475.25	12.42	-	884.84
2005	327.54	565.41	70.31	-	963.26
2006	792.07	764.46	22.42	-	1,578.95
2007	767.92	616.47	50.59	-	1,434.98
2008	560.93	785.23	34.79	1.84	1,382.79
2009	773.18	1,561.58	28.52	0.07	2,363.35
2010	1,110.50	1,959.84	65.28	21.50	3,157.12
2011	1,093.02	862.18	67.70	36.57	2,059.47
2012	1,209.51	956.07	71.71	8.44	2,245.73
Sub-total	8,297.31	8,858.30	438.68	68.43	17,662.63
Total	17,662.63		438.68	68.43	17,662.63

Source: Adami Tulu Pesticide Processing Share Company, 2013

Pesticides unregistered in EU but in use in Ethiopia

Some pesticides used widely in Ethiopia are not registered (prohibited) for use in European countries (Table 4). Endosulfan and its related isomers, which are included under the POPs list in the Stockholm convention, are still in use and being formulated at the Adami Tulu pesticide formulation plant.

Table 4. Pesticides being used in Ethiopia but not registered in European countries

Trade Names	Common Names	Pesticide Types
ACE 750 SP	Acephate	Insecticide
Agro-Lambacin Super 315 EC	Profenfos 30% + Lambda-Cyhalothrin 1.5%	Insecticide
Ethiolathion 5% Dust	Malathion (Banned as plant protection product)[2]	Insecticide
Ethiolathion 50% EC	Malathion	Insecticide
Ethiosulfan 25% ULV	Endosulfan	Insecticide
Helmathion 50 Ec	Malathion 50% EC	Insecticide
Malathion 50% EC	Malathion	Insecticide
Malt 50% EC	Malathion 500 gm/lt	Insecticide
Marshal 20 UL	Carbosulfan	Insecticide
Marshal 25% EC	Carbosulfan	Insecticide
Marshal 25% ULV	Carbosulfan	Insecticide
Marshal/Suscon	Carbosulfan	Insecticide
Sumithion 96% ULV	Fenitrothion	Insecticide
Sumithion 95% ULV	Fenitrothion	Insecticide
Ametrazine 500 SC	Atrazine 250 gm/lt + Ametryn 250 gm/lt	Herbicide
Gesaprim 500 FW	Atrazine 500g/l	Herbicide
Queletox UL 600	Fenthion	Avicide
Mitac	Amitraz	Miticide
Mitigan 18.5EC	Dicofol	Miticide
Thiodan 25% ULV	Endosulfan[3]	Insecticide

Source: PAN-Ethiopia, 2014

The ratification of international chemical conventions and formulation of national policy frameworks has not been fully enforced in the Ethiopian situation. The issue of pesticide impacts on human health and the environment has been raised by different actors but not in a concerted and coordinated manner. Universities and research centers conduct research that may not be read by the grassroots actors for action. For someone who is interested in studying the pesticide poisoning magnitude in the country, it is very difficult to obtain secondary data from health institutions and most pesticide poisoning

[2] PPDB, list of band pesticides in EU (2008), PAN Europe banned pesticides list (http://www.pan-europe.info/Archive/Banned%20and%20authorised.htm#banned, 2009), UTZ list of banned pesticides and pesticides watch list (www.utzcertified.org, (2014).

[3] POP

cases (usually the most acute) are reported to the media by police rather than health personnel.

These issues reveal that the adoption of international conventions into national policy frameworks and setting up of institutions for implementation alone did not solve pesticide-related problems in the country. This was the basis on which further exploration of the overall pesticide management situation in Ethiopian agriculture was initiated in this study.

3.6 Study Area and problems

National overview

Ethiopia is one of the world's rich biodiversity countries, which deserves attention regionally and globally (Vavilov, 1951). It has a very diverse set of ecosystems ranging from humid forest and extensive wetlands to the desert of the Afar depression (Awas et al., 2003, IBC, 2005, IBC, 2009). This is due to the variation in climate, topography and vegetation (IBC, 2009).

The flora of Ethiopia is very diverse with an estimated number of between 6,500 and 7,000 species of higher plants, of which about 15 per cent are endemic. It is claimed that Ethiopia has the fifth largest flora among tropical African countries (IBC, 2005). The extensive and unique conditions in the highlands of the country have contributed to the presence of a large number of endemic species. It is not only the wild flora that exhibits this characteristic: Ethiopia is one of twelve ancient countries harboring extensive crop plant diversities. Its valuable reserves of crop genetic diversity include 11 cultivated crops that have their centre of diversity in the country (Vavilov, 1951).

A total of 42 species of endemic mammals are found in Ethiopia. Among these are six larger mammals (Walia Ibex (*Capra walle)*, Gelada Baboon (*Theropithecus gelads)*, Starck's Hare (*Lepus starcki)*, Mountain Nyala (*Tragelaphus buxtoni),* Bale Mountains Vervet *(Chlorocebus djamdjamensis*) and Ethiopian Wolf (*Canis simensis)*) and the remaining are comprised of smaller animals, including 3 species of bat, 8 shrews and 25 rodent species (Wilson and Reeder, 2005).

The larger mammals are mainly concentrated in the south and southwest border regions and adjacent areas of the country. There are also plentiful plains along the stretch of the Great Rift Valley System. Two hundred and seventy seven species of mammals, 861 species of birds, 201 reptiles (87 snakes, 101 lizards and 13 species of tortoises and turtles), 145 species of freshwater fish, of which over 87 species are from the Baro River and 16 from Lake Abaya, 324 butterflies and 63 species of amphibians are known from Ethiopia (IBC, 2005).

In terms of its avifauna, Ethiopia is one of the most significant countries in mainland Africa from a biodiversity perspective. The country's diverse habitat types contribute to the tremendously diverse avifauna; over 861 endemic birds are recorded from Ethiopia. At present, 69 Important Bird Areas (IBAs) are identified by the Ethiopian Wildlife & Natural History Society (EWNHS and BLI, 1996).

The diversity of ecosystems of Ethiopia has been described in a number of reports and publications (Awas et al., 2003, IBC, 2005, IBC, 2009). Classification of these ecosystems is based on vegetation types, which describe the composition of dominant plant species in the respective ecosystems (Demissew et al., 1996, EPA, 1997, Friis et al., 2010, Woldu et al., 1999). The classification of ecosystems in Ethiopia is: Afroalpine and Sub-Afroalpine, Dry Evergreen Montane Forest and Grassland Complex, Moist Evergreen Montane Forest, *Acacia-Commiphora* Woodland, *Combretum-Terminalia* Woodland, Lowland Semi-Evergreen Forest, Desert and Semi-Desert Scrubland and Wetland Ecosystem (IBC, 2005).

These ecosystems are geographically located in different highlands, mid-altitudes and lowlands and harbor unique and diverse biological diversity (floral, faunal and microbial species composition). The variation in the species' composition across the stated ecosystems might be attributed to variability in climatic and other associated factors within the ecosystems. However, these ecosystems are found under pressure of growing human and livestock population in the surrounding areas. Subsequent expansion of agricultural and deforestation (especially fuel wood extraction), fire, overgrazing and expansion of indigenous and exotic invasive species such as *Prosopis juliflora,* soil erosion and land degradation, siltation, settlement, climate change and pollution are among the factors threatening the ecosystems (EIB, 2014).

National agro-ecosystems

Ecological conditions usually relate to climatic parameters, such as amount of rainfall, rainfall variability, temperature, vegetation characteristics, and finally, soil and water characteristics, which are further important parameters that permit ecological differentiation (Conway, 1985; Hurni, 1998). In Ethiopia, two classifications of agro-ecological zonation are known: the traditional agro-ecological zones and the elaborated agro-ecological zones developed by the Ministry of Agriculture and the Ethiopian Institute of Agricultural Research. The traditional zones include Bereha, Kolla, Woina Dega, Dega,Wurch and Kur, and many types of crop are grown in each of these ecological zones. On the other hand, 33 elaborated agro-ecological zones are recognized by other institutions, and many kinds of crop are also grown in each zone. In these agro-ecological zones, major external inputs (fertilizers and pesticides) are used in crop production, which has implications for input distribution and pest management (Gorfu and Ahmed, 2003).

The Ethiopian Rift Valley

The Ethiopian Rift Valley, where the present study was conducted, is among the government's target areas for agricultural intensification where there are large, commercial agricultural investments in addition to smallholder farmers. Both bush clearance for agricultural expansion and agro-chemical use have been increasing from time to time by large farms and smallholders. Land use change is another factor that can have an impact on biodiversity. The conversion of natural vegetation is currently one of the leading agendas for a number of world conservation organizations, authorities and interest groups (UNDESA, 2004).

In both the Central and Southern Rift Valley areas, there is extensive agricultural activity where there are both smallholder farmers and big commercial farms. Commercial farms around the Central Rift Valley (Ziway) area are cut-flower and vegetable producers while those in the Southern Rift Valley (Arba Minch) area are cotton, vegetable and fruit producers. Smallholder farmers in both areas produce cereals such as maize, sorghum and teff during rainy seasons. Smallholder farmers in the Ziway area are highly engaged in vegetable production through the use of irrigation from Lake Ziway. In the Arba Minch area, smallholder farmers produce fruits (banana, mango, avocado, and so on), cereals, cotton and vegetables by using irrigation from the Kulfo, Sille and Haria rivers and other relatively smaller streams. Smallholders in this area do not pump out water from the Abaya and Chamo lakes for irrigation purposes. Previously, vegetable production was not common in the Arba Minch area, but it is becoming a common practice these days, which has also had implications in increasing the use of agricultural inputs. Agriculture intensification, population pressure and recurrent drought are among the interrelated causes that are threatening the medium and long-term functional integrity of its ecosystem (IBC, 2005).

The Rift Valley of Ethiopia, which runs diagonally from the Northeast down to the Southwest, contains a number of ecosystems including wetlands (both riverine and lacustrine), savannah woodlands and grasslands and desert and semi-desert vegetation. The Southern and middle Ethiopian Rift Valley is characterized by Acacia-Commiphora woodland and aquatic ecosystems. It is found between 900 and 1,900m above sea level. The characteristic woody species of this ecosystem include *Acacia senegal, A. seyal, A. tortilis, A. mellifera, Boswellia microphylla, Balanites neglecta, B.aegyptiaca,* *Commiphora africana, C. myrrha, C. boranensis, C.cilliata, C. monoica* and *C. serrulata*. These species are characterized by either small deciduous or leathery persistent leaves. Species of *Acalypha, Barleria, Aerva* and *Aloe* are also common in Acacia-Commiphora Woodland Ecosystems (IBC, 2005, IBC, 2009). Of all the various ecosystems of Ethiopia, the Rift Valley region is one of the most threatened by high pressure from agricultural development. It has rich volcanic soils which have the potential of being significantly developed as agricultural land. Though liable to salinization, the potential for extensive arable cultivation with regard to monocultures (cotton, vegetables, sugarcane, cut flowers, etc.) is high. This section of the country has undergone great agricultural changes in the past, with devastating effects on biodiversity.

Characteristic wild mammals such as Oryx, Swayne's Hartebeest, Kudu, Gazelle, African Wild Ass, Grévy's Zebra, Waterbuck, Serval Cat, Elephant, Buffalo, Dibatag (Clarke's Gazelle), Gerenuk (Long-necked Antelopes) and other animals inhabit this ecosystem. The characteristic birds include Ostrich, Hunter's Sunbird, Shining Sunbird, Golden-breasted Bunting, Salvadori's Seed Eater, Yellow-throated Seed Eater, Ruppell's Weaver, White-headed Buffalo Weaver, Golden-breasted Starling, White-tailed Swallow and Stresemann's Bush Crow (IBC, 2005; 2009). It is also a major migratory flyway, with over 400 migratory bird species recorded, including the Great White Pelican, Greater and Lesser Flamingo, Ostrich, Imperial Eagle, Lesser Kestrel and Wattled Crane (EWNHS and BLI, 1996, IBC, 2005, IBC, 2009).

The Rift Valley lakes basin has over 25 fish species and accounts for about 50% of total inland fish production. The most important commercial types of fish are tilapia, Nile perch and catfish. In addition to this, most of the National Parks (Abijata-Shala Lakes National Park, Nechisar National Park, Omo National Park and Mago National Park) in the country are found in this valley (IBC, 2005). Figure 1 below shows a map of the Ethiopian Rift Valley with reference to the villages where the study was conducted.

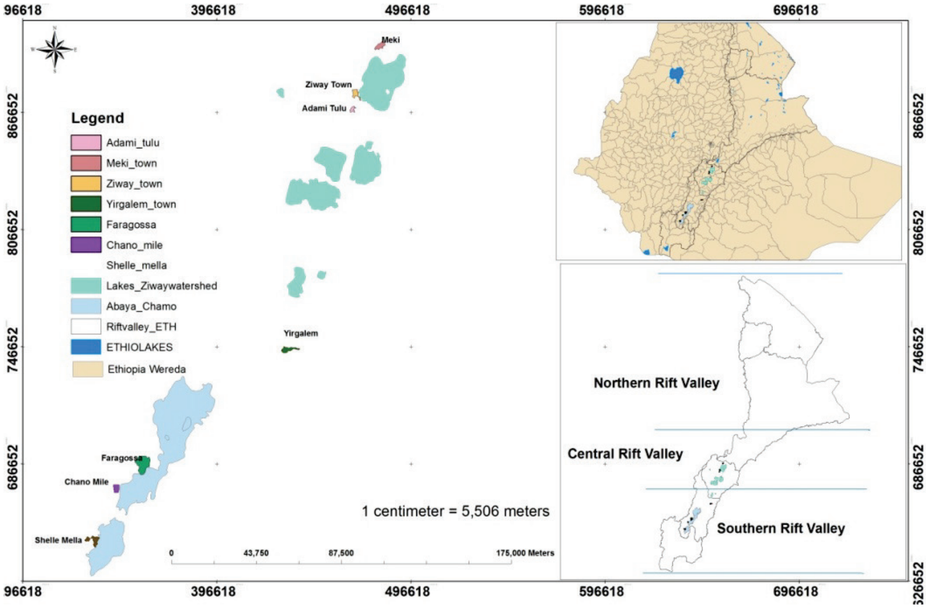

Figure 1. The Ethiopian Rift Valley area (Source: Google maps).

Agricultural expansion and impacts of pesticides

Pesticides present the only group of chemicals that are purposefully applied to the environment to kill wildlife with the aim to suppress plant and animal pests and to protect agricultural and industrial products. However, the majority of pesticides are broad spectrum and do not only affect targeted pest populations: their application invariably affects non-target plants and animals (PAN-Europe, 2010) too. It is estimated that less than 0.1 percent of the applied pesticide reaches the target pest, leaving 99.9 percent as a pollutant in the environment, including the soil, air, and water, or on nearby vegetation (Pimentel, 1995).

Many pesticides are not easily degradable, some persist in soil, some leach into groundwater and some contaminate surface water and the wider environment (IBC, 2005). Depending on their chemical properties, they can enter organisms, bio-accumulate in food chains and consequently also influence human health (PAN-Europe, 2010). As repeated application has the potential to increase pesticide resistance of targeted pests (PAN-Europe, 2010), a common response of farmers is to increase dose rates or apply pesticide cocktails.

The effect of pesticide on non-target organisms is also immense. It has been reported that about ten million non-target organisms, including thousands of domestic animals, are poisoned each year throughout the world (Piementel et al., 1992). Moreover, pesticides often disrupt the population of natural enemies, leading to lack of biological control in agriculture, thus resulting in food loss due to pests. Pollination processes can also be impacted as wild bees are vital for pollination of about one-third of fruits, vegetables and other crops worldwide (Pimentel et al., 1997), with domesticated bees also sometimes affected, also impacting pollination processes as well as affecting the provision of honey as a 'crop' or yield. Wild birds and mammals are also at risk from the application of pesticides.

In a recent study conducted in an Italian agricultural area, the species richness of wild bees, bumblebees and butterflies was sampled after pesticide application. They detected a decline in the number of wild bees after repeated application of the insecticide fenitrothion and lower bumblebee and butterfly species richness was found in the more intensively farmed basin with higher pesticide loads (Brittain et al., 2010).

Avicides, insecticides and rodenticides are the key pesticides presenting risk of direct harm to birds. Insecticides account for less than 20% of pesticide use generally (in North America), but are more prevalent in developing countries. Herbicides account for nearly half of the pesticides used in North America, insecticides 19%, fungicides 13%, with the remaining 22% including a variety of other products (Gianessi and Silvers, 2000). Bird species that inhabit farmland or use farmland during migration are at risk. Waterfowl and certain game birds that feed on agricultural foliage are at potential risk. Birds that feed on earthworms and agricultural pests such as grasshoppers, caterpillars, beetle larvae and termites are at risk if they are contaminated. Scavengers and predators are also poisoned when they consume contaminated prey (Mineau, 2009).

It is estimated that worldwide bird populations have declined by 20 to 25% since pre-agricultural times. Altogether, 1,211 bird species (12% of the total) are considered globally threatened, and 86% of these are threatened by habitat destruction or degradation. For 187 globally threatened bird species, the primary pressure is chemical pollution, including fertilizers, pesticides and heavy metals entering surface water and the terrestrial environment (BLI, 2004).

Of all the components of agricultural intensification (after land is cleared for agriculture), the use of pesticides and especially insecticides and fungicides, has had the greatest negative effect on species diversity (IBC, 2005). The use of pesticides has increased dramatically over the past 60 years worldwide (Amera and Abate, 2008). Historically, chemical pesticide use in Ethiopia was low, but recent developments in increased food production and expansions in the floriculture industry have resulted in higher consumption (Amera and Abate, 2008). Pesticide use in Ethiopian state farms is estimated at 7.76kg/ha/yr, with usage of less than 0.1kg/ha/yr in smallholder farms (PAN-UK, 2006). In Ethiopia, the intensity of pesticide application is highest in the commercial greenhouses of the cut-flower farms (Emana et al., 2010) and commercial cotton farms.

As the Rift Valley area attracts private investors in agriculture and especially cotton, horticultural crops and flowers, it is pressurized by intensive use of agrochemicals and irrigation (Emana et al., 2010). The water bodies are also affected by harmful agricultural practices and over-fishing (IBC, 2005). The Meki and Katar rivers, and the Bulbula and Gogessa rivers, which flow into the lakes of Ziway and Abijata respectively, are being used for irrigation, and this has subsequently decreased the water level of the lakes and resulted in drastic effects on the fish and other aquatic communities of the lake. Fish species such as *Oreochromis niloticus*, the Nile tilapia, which spawns in shallow parts of the lake, are adversely affected by the change in water level.

Although a systematic study on the impacts on biodiversity in general and birds in particular in the Ethiopian Rift Valley has not yet been undertaken, preliminary assessments (surveys) (Amera and Abate, 2008) and personal communication with residents (Wondafrash, 2013) indicate that the bird (both migratory and resident) population has been dwindling over the last 3-4 decades, with this phenomenon being partly attributed by many observers to unabated, unwise and excessive use of agrochemicals.

Accordingly, there is a widely accepted public perception that the impacts of pesticides on birds are associated with the:

- Fast expansion of horticulture in general and floriculture in particular, which rely heavily on pesticide use against a montage of pest complexes,
- Introduction of invasive alien pest species (e.g. *Tuta absoluta* on tomato, African invasive fruit fly on fruit crops and cotton mealybug), and
- Increased status of bird pests e.g. *Quelea quelea* on sorghum, maize and sugar cane, due to which a large number of avicides are sprayed from the air annually.

Several of the lakes within the central and southern Ethiopian Rift Valley have been designated as Important Bird and Biodiversity Areas (IBAs). They host diversified bird species (residents and migrants) that need an uninterrupted food supply for reproduction, resting stages, roosting sites and freedom of movement to defend themselves from natural enemies. These lakes have, however, been the victim of pollutants from both point and non-point sources (Ewnhs and Bli, 1996).

A study by Emana et al. (2010) indicated that Lake Ziway and Langano (central Rift Valley), and Abaya (southern Rift Valley) have been contaminated with varied pesticides in large amounts, which have been applied for control of different crop pests (weeds, birds - both invasive and resident) to safeguard the productivity of a high concentration of large and small scale farms in these areas. (Emana et al., 2010).

Pesticides have also been reported as risks to the health of Ethiopian farmers. The lack of personal protective equipment, inappropriate handling and application practices, misuse and abuse such as treating human and animal subjects for ectoparasites as well as mixing cocktails of pesticides (often with bare hands) “to improve” efficacy, using internationally banned pesticides and a low level of practice in responsible management of pesticides are amongst the main reasons mentioned for increased acute and chronic human health risks (Matthews et al., 2003; Williamson et al., 2008).

These issues have been a topic of discussion since I became involved in the pesticide-related dialogue in the Africa Stockpiles Program in 2005. The human health impact of pesticides, however, continues to recur every now and again. The traditional approach of managing the problem has been through national proclamations and regulations to control the situation and through international conventions that lay down obligations. However, these policy frameworks are usually scarcely enforced or not enforced at all, but create a way for further agriculture modernization and expansion with a piecemeal approach and poor sense of responsibility to tackle root problems. This issue finally received special attention by the Ministry of Agriculture of Ethiopia (MoA), the Desert Locust Control Organization for Eastern Africa (DLCO-EA) and the United States Agency for International Development (USAID). These three organizations took the initiative, inviting all actors in the Pesticide Delivery System (PDS) of Ethiopia for a consultative meeting in 2008. I was also invited as a representative of the Pesticide Action Nexus Association of Ethiopia (PAN-Ethiopia) and became interested in following the progress of the dialogue of actors. This gave an opening for networking all actors in the PDS for a systemic approach to cultivating stewardship through social learning across all levels. A research project was therefore designed and methodology was developed to approach the entire process of interaction from national (meta), through regional (meso) down to local (micro) level; and analysis of the contribution of each level in the dialogue process to the wider overarching goal of the system-wide pesticide users’ stewardship was conducted.

3.7 Thesis Objectives and Research Questions

Objectives

The pesticide *problematique* outlined above has been addressed through an attempt to improve the state of affairs of the national pesticide delivery system and to transform it through an effective program of system-wide stewardship. The socio-economic, political, cultural and institutional aspects of the present situation were examined in terms of their influence on what was being attempted at national, regional and local levels as change processes through this study. Environmental Communication provided the lens through which to understand the specific conditions prevailing at different levels pertaining to Ethiopian society and its food and agricultural sectors, yielding a new understanding and opportunities for further action around the complex situation of pesticide issues. These are elaborated in the chapters to follow.

Therefore, the more specific objectives of the thesis were:

- to investigate the application of 'pesticide users' stewardship' as a concept as well as a means to address the complex pesticide situation, and its effectiveness in achieving responsible management of pesticides in Ethiopian agriculture, and

- to establish the factors influencing the adoption of a system-wide pesticide stewardship network in areas prone to public health and environmental impacts of pesticides in the Ethiopian Rift Valley.

Research questions

In view of achieving the stated objectives, the study focused on the following research questions:

I What communicative, systemic, organizational and societal barriers would need to be overcome when facilitating transformative learning around the concept of pesticide stewardship at different levels of the pesticide delivery system?

II How feasible, valid and effective would a multi-stakeholder, system-wide, action-oriented, policy-directed network of key actors be in addressing the pesticide problem?

4 Conceptual Framework

The pesticide and human health issues in developing countries and in Ethiopia have not been assessed from the pesticide user's stewardship point of view. The PhD process was aimed at investigating the application of 'pesticide users' stewardship' as a concept as well as a means to address the complex pesticide situation, its effectiveness in achieving responsible management of pesticides in agriculture, and to establish the factors influencing the adoption of a system-wide pesticide stewardship network in areas prone to public health and environmental impacts of pesticides in the Ethiopian Rift Valley. This was approached at three levels of the pesticide delivery system of Ethiopia: at meta, meso and micro levels. The first, meta level approach was at a national policy makers and experts level so as to deal with the issue in relation to international agreements and national regulatory frameworks. The second, meso level approach was at a regional level so as to deal with pesticide risk communication through the lens of environmental communication. The third, micro level approach with smallholder cotton farmers deals with a regular session of farmer field schools.

In order to test the applicability of the ethics of the pesticide users' stewardship notion at the three levels mentioned above, the thesis builds on concepts of stewardship, transformative learning and experiential learning and links specific cases with risk communication and institutional innovation.

4.1 Stewardship

Stewardship is not a theory by itself but there is literature that links different theoretical models to stewardship attitudes and behavior. This thesis uses the transformative leaning theory of Mezirow (1991) to link the adult learning process with the specific use of the term in relation to the negative impacts of pesticides on human health and the environment within the context of Ethiopian agriculture.

The word *stewardship* is used by religious organizations, government agencies, chemical companies, universities and others. The common use of the word reflects responsibility for the wise use and management of natural resources. When it is used in the natural resource management context, it takes on the concept of "sustainability", which indicates the balanced account of the present society, future generations and other species (Worrell and Appleby, 2000). In its broader approach, this comprises anthropocentric and eco-centric concepts which became the foundation for the biggest applications of the word in forest stewardship council, marine stewardship council and many more natural resource use/management fields to exemplify institutionalized ways of promoting responsible behavior among users. This being the common use of the word by many of the groups, some definitions include an ethical and moral component. The ethical or moral obligation for different groups refers to God, future generations, long term economic benefits, society or a combination of some or all of these. Table 5 has adopted some of the definitions from Hockett et al. (2004) and indicates different definitions of stewardship from an environmental perspective.

Table 5. Stewardship definition used in different literature

Source	Definition
Dixon et al. 1995 in Fedler 2001 (Fedler, 2001)	Stewardship is the moral obligation to care for the environment and the actions undertaken to provide that care. Stewardship implies the existence of an ethic of personal responsibility, an ethic of behavior based on reverence for the earth and a sense of obligation to future generations. To effectively care for the environment, individuals must use resources wisely and efficiently, in part by placing self-imposed limits on personal consumption and altering personal expectations, habits, and values. Appropriate use of natural resources within the stewardship ethic involves taking actions that respect the integrity of natural systems.
(Holsman, 2000)	Personal Stewardship: A moral norm with altruistic motivations that necessitates personal action by individuals. Agency or Institutional Stewardship: refers to the institutional mission to conserve and sustain wildlife and ecosystems in the public trust. A cultural value whereby agencies take on the moral and legal obligation of maintaining the resource on behalf of the public trust.
(Leopold, 1933; Leopold, 1970)	Application of forest management within the context of a land ethic.
(Worrell and Appleby, 2000)	Stewardship is the responsible use (including conservation) of natural resources in a way that takes full and balanced account of the interests of society, future generations, and other species, as well as of private needs, and accepts significant answerability to society (and ultimately to God).

Source	Definition
University of Michigan 2004	Stewardship is the concept of responsibly managing all of our resources for the benefit of present and future generations of people, plants, and animals.
Webster's Dictionary 2004	**1 :** the office, duties, and obligations of a steward **2 :** the conducting, supervising, or managing of something; *especially* **:** the careful and responsible management of something entrusted to one's care, "*stewardship* of our natural resources"
Interfaith Council for Environmental Stewardship 2004	Men and women were created in the image of God, given a privileged place among creatures, and commanded to exercise stewardship over the Earth. Human persons are moral agents for whom freedom is an essential condition of responsible action. Sound environmental stewardship must attend both to the demands of human wellbeing and to a divine call for human beings to exercise caring dominion over the Earth. It affirms that human wellbeing and the integrity of creation are not only compatible but also dynamically interdependent realities.
(Hockett et al., 2004)	Environmental Stewardship is the concept of teaching young people how to proactively serve their communities as conservators and protectors of the environment. The specific goals of the Environmental Stewardship program include: understanding ecological concepts, building an awareness of environmental issues and values, developing scientific investigatory and critical thinking skills, and learning skills needed for effective action.
Context of this thesis	Pesticide users' stewardship is the responsible management of pesticides in a way that minimizes/avoids possible hazards to human health and the environment

Source: Adopted from Hockett et.al. (2004)

Environmental stewardship

The term stewardship has been used by different Christian theologians with a notion affirming that God has made people caretakers and protectors of the rest of creation. Lynn White Jr., in his essay in 1967, however, linked the ecological crisis with Christianity with a strong statement saying "*Especially in its Western form, Christianity is the most anthropocentric religion the world has seen*" (White, 1967). White argued that the roots of the ecological crisis were religious and suggested that the solution was also religious. This argument became a point of debate by many Christian and non-Christian writers. The theologians wrote about the role of Christianity in environmental stewardship, referring to the Bible regarding humans' distinctiveness and a special relationship between humans and God while also placing limits on human freedom and dominion over the rest of nature.

The naturalist and author Aldo Leopold, who is recognized as the one who began the philosophy of the ethic of stewardship, wrote "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect" (Leopold, 1933). This became the basis for the establishment of forest stewardship initiatives. The forest stewardship council has been one of the strong non-profit, multi-stakeholder alia which sets rules and plays a role as an actor of private forest politics beyond the state (Pattberg, 2005).

Product stewardship

The use of the word *stewardship* in recent years has diverted from its original use in natural resource management towards the protection of the environment from waste of industrial products through product stewardship. One of the areas of application for product stewardship has been the emergence of the widespread accumulation of solid waste from packaging. The packaging industry brought modern systems of production and consumption which succeeded in transporting products over long distances and through many steps in the supply chain without damage; to store food products for much longer periods and often without refrigeration; to display and sell products efficiently in retail stores; and to provide pre-prepared food and beverages in a wide variety of different forms and portions. However, consuming large quantities of material for the manufacture of 'single-use' products, and the impacts of disposal after use had been a concern to many communities, environmental groups and governments.

Alvin Toffler, as cited in Lewis (2005), coined the term 'throw-away society' to describe the trend towards 'the economics of impermanence' and to products that have a short life:

> We develop a throw-away mentality to match our throwaway products. This mentality produces, among other things, a set of radically altered values with respect to property […] Instead of being linked with a single object over a relatively long span of time; we are linked for brief periods with a succession of objects that replace it. (Lewis, 2005; Toffler, 1970)

The public concern about plastic packaging has been the amount of time it remained in the environment without degrading or decomposition. This urged the packaging industry to act with the development of codes of conducts on responsible care of after use waste, and the term "product stewardship" was coined by the Canadian and American chemical industry associations to deal with a new approach to the life cycle management of chemicals with "responsible use". The responsible use component was, however, not clearly defined with regard to whether it should be the manufacturer or the consumer that took responsibility for the environmental protection in relation to the items used. This resulted in the concept of "Extended Producers' Responsibility (EPR)" in Europe by a Swedish professor from Lund University (Lindhqvist and Lidgren, 1990) and its adoption by the United States with the term "Product Stewardship" as a means for a shared responsibility approach to managing at end-of-life. Even though there was still a debate concerning who should take responsibility in the developing world, the first essence of product stewardship did not depart from the origin of “environmental stewardship” with a push to protect the environment from synthetic chemicals. Lindhqvist (1992), for instance, defined extended producer responsibility as follows:

> […] an environment protection strategy to reach an environmental objective of a decreased environmental impact of a product, by making the manufacturer of a product responsible for the entire life-cycle of the product and especially for the take-back, recycling and final disposal of the product. (Lindhqvist, 1992)

Lindhqvist argues that the responsibility for the chemicals management in designing, manufacturing, use, recycling and disposal should be taken by the manufacturer with a full understanding of how to protect the environment from the deleterious impacts caused by the end-of-life products, and the manufacturer should take back the end-of-life item from the end user. The entire life cycle approach and especially the take-back systems have been well implemented in developed countries compared to the actions taken in this respect in developing countries. Leaving aside the less hazardous packaging materials (such as plastics) management; many highly hazardous chemicals are still coming to the market of the developing world with a minimum or no binding pledge of EPR. The Bhopal incident in 1984, one of the tragic events of our time, shows how chemicals can affect human beings and the entire community, and is an example that shocked the chemical industry into questioning whether “product stewardship” in its full life cycle approach was implementable.

Pesticide stewardship

The US Environmental Protection Agency (EPA) and the U.S. Department of Agriculture initiated the Pesticide Environmental Stewardship Program (PESP) in 1994 (EPA, 2004). It brought together pesticide users from agricultural and non-agricultural settings with a goal to encourage stakeholders to voluntarily adopt strategies and management practices to achieve pollution prevention and reduce risks posed by pesticides to human health and the environment. Unlike the adoption of EPR by Europe as part of government regulation to be enforced by laws, legal enforcement has generally been avoided in the US in favor of voluntary approaches, reflected in terminology such as ‘product stewardship’ or ‘extended product responsibility’, which has also been the case for pesticide environmental stewardship programs (EPA, 2004). The voluntary actions in which the pesticide regulators, the industry and educators agree to be engaged included pesticide container recycling, certification of applicators and setting worker protection standards, formulating pesticide label language and pesticides and pesticide container disposal options.

There were other initiatives in turn, such as the establishment of the pesticide stewardship partnership in Oregon in 2000, which was coordinated by the Oregon Department of Environmental Qualities (Masterson, 2012) so as to identify potential problems and improve water quality associated with pesticide use. This initiative focused on protection of water bodies from pesticide pollution. Their detailed activities range from identifying local pesticide related water quality issues to sharing water quality monitoring results with water users, setting water quality criteria, looking for solutions related to pesticide pollution problems and conducting long-term monitoring to measure success and provide feedback to support water quality management. All these pesticide stewardship initiatives, in their establishment, claim that they focus on the protection of human health and the environment from harm posed by pesticides.

The pesticide industry represented by its members' association, Crop Life International, also has its version of pesticide stewardship. Crop life International coordinates the international market of pesticides and it has branches in many countries. The Crop Life International version of pesticide stewardship is "*The responsible and ethical management of a plant protection or biotechnology product throughout its life cycle to support sustainable agriculture*" (Jones, 2006). This definition, however, dilutes the very essence of product-related environmental stewardship in its way of taking the stewardship concept to protect the product rather than the users or the environment. It has a sense of the usual way of promoting pesticides and the plant protection biotechnology without mentioning the "risks" and "hazards" they may pose to human health and the environment. This argument makes sense especially if the actual situation in sub-Saharan Africa is looked into. There is evidence showing the external health costs of pesticide use by projected to reach US$90 billion by 2020 (UNEP, 2012). The 2005 estimate is compared with the total overseas development assistance to health in the region (excluding for HIV/AIDS) of US$4.8 billion. Yet, governments were not able to consider the external costs of pesticides in their development policies and the "ethical" pesticide stewardship program of the industry never touched upon this. The chronic effects of pesticide exposure resulting in unhealthy and less productive citizens (Frazzetto et al., 2012; Idris et al., 2012) should be considered when an "ethical" approach to pesticide stewardship is designed. Looking at the negative human health and environmental impacts that have been reported so far (and not very well attended to) (Bouwman, 2012; Hogarh et al., 2013; Idris et al., 2012; Ogah and Coker, 2012), the ethic of pesticide stewardship should focus on "Users' stewardship" for a better and more sustainable agriculture that guaranties the continuation of the future generation. The contextual meaning of the ethic of pesticide users' stewardship in this thesis is, therefore, "*the responsible management of pesticides in a way that minimizes/avoids possible hazards to human health and the environment*".

Stewardship payments

The issue of stewardship incentives has been considered as part of the government policies encouraging citizens to act in a proper way and to be compensated for what they do. With the recognition of the problems associated with agriculture modernization, policy reforms have been conducted in the EU and the US since 1980s. The agri-environmental stewardship program launched in 1986 in the UK was followed by the countryside stewardship scheme in 1991 (Dobbs and Pretty, 2004) and then by the environmental stewardship scheme in 2005 (Quillérou and Fraser, 2010). These programs gave incentives to farmers for different aspects of stewardship they managed to accomplish. The first category these stewardship incentive schemes favored were actions that avoided negative externalities such as inorganic fertilizers and pesticides and restrictions on the use of agrochemicals near water bodies where the areas are categorized as nitrate vulnerable zones. This category is related to the provision component of the ecosystem services where the agriculture sector is engaged to provide food, fresh water, fuel, wood and fibers. The second category of the stewardship incentive scheme is a conservation-based scheme that appreciates the non-food, non-fiber contribution of the agriculture sector engaged in production of positive externalities or public goods; also known as the provider-gets principle. This category includes eco-system services ranging from supporting services to regulating services and cultural services. The supporting services are mainly nutrient recycling, soil formation and primary production; the regulating services consist of climate regulation, flood regulation, disease regulation and water purification; and the cultural services consist of aesthetic, spiritual, educational and recreational services (Watson and Zakri, 2005). This includes incentives in relation to producing wildlife habitats, maintaining countryside landscapes and creating good scene. Similar stewardship payment schemes have also been issued in the US, but their application is limited to developing countries. The application of environmental stewardship in the developing world adopted the early model of the wilderness conservation approach of the United States in the creation of national parks, which involved the removal of people from parks and their resettlement outside of park boundaries. As Swallow writes "*Access to the park was largely restricted to local community members, managed by a system of "fences and fines*", which is still the case in most developing countries (Swallow et al., 2009). Compensation mechanisms in the case of Nairobi National Park, for example, is limited to the damage caused by wildlife to livestock and crops and with a reward mechanism for land owners who maintain wildlife corridors (Ochieng et al., 2007). Other mechanisms of environmental schemes are, however, not well known in many parts of the developing world.

Compensation mechanisms, however, had been criticized due to the fear that may lead farmers to adverse selection of environmental stewardship schemes compared to the other options of optimal utilization of their land (Quillérou and Fraser, 2009). Others have a greater appreciation of the environmental movement, with thousands of volunteer activists influencing international and national policies and bringing actual change to grassroots communities. Volunteer motivation and the dedicated commitment of volunteers is believed to bring actual change through environmental stewardship (Ryan et al., 2001).

4.2 Transformative learning

In order to understand the notion of a system-wide pesticide users' stewardship and the learning experiences at meta, meso and micro levels, transformative learning theory was used to analyze the findings of this thesis. Jack Mezirow (1978) first introduced the theory of transformative learning (Mezirow, 1978), which helped to explain how adults changed the way they interpreted their world (Taylor, 2008). As Mezirow's transformative learning is much influenced by Paulo Freire and Jürgen Habermas (Kitchenham, 2008), this thesis draws mainly on different sections of their thoughts.

Human beings continuously endeavor to give meaning to their daily lives based on interactions and communication at a narrow or wider level. Transformative learning helps to understand the process of change in these human interactions. According to Mezirow (1997), transformative learning (Cranton, 1994; Cranton, 1996; Mezirow, 1991; Mezirow, 1996) "*is the process of effecting change in a frame of reference"*. Frames of reference in Mezirow's context are the structures of assumptions through which humans interpret and understand their experiences and set a "*line of action*" to automatically move from one specific activity (mental or behavioral) to another. Individuals usually tend to stick to their own preconceived frames of reference and tend to reject ideas that do not fit into their preconception. A frame of reference is composed of two dimensions: *habits of mind* and *a point of view* (Mezirow, 1997). Habits of mind are habitual ways of thinking, feeling, and acting influenced by assumptions of the cultural, social, educational, economic, political, or psychological set up of the individual learner. Habits of mind are also articulated in a specific point of view – the constellation of belief, value judgment, attitude, and feeling that shapes a particular interpretation. An example of the habit of mind in the Ethiopian Rift Valley smallholder farming system context is limiting women's activities at household level to cooking food for the household and taking care of the kids; in contrast to men's role in farming activities and participating at farmer field schools and other training. Habits of mind are more durable than points of view. Points of view are subject to continuing change based on access to awareness and feedback from others, whereas habits of mind are a complex of feelings, beliefs, judgments and attitudes that operate out of the awareness of the individual.

According to Mezirow (1990), learning is the process of making a new or revised interpretation of the meaning of an experience, which guides subsequent understanding, appreciation and action (Mezirow, 1990). Moreover, a set of assumptions that structure the way individuals interpret their experiences is influenced by habits of expectation that constitute their frame of reference. The habits in making meaning through interpretation are, therefore, considered an important constituent of understanding the nature of adult learning. Making meaning will also be considered learning when interpretations are used to guide decision making or action. The meanings made attached to learners' experience may, however, be subjected to explicit assessment of the consequence and the origin of meaning structures, which Mezirow calls critical reflection (Mezirow, 1990). According to Mezirow, "*critical reflection is a process by which we attempt to justify our beliefs, either by rationally examining assumptions, often in response to intuitively becoming aware that something is wrong with the result of our thought, or challenging its validity through discourse with others of differing viewpoints and arriving at the best informed judgment*". This helps to validate the habits of expectation which are not merely taken-for-granted actions or reactions that repeat themselves endlessly, and to justify what we have learned through the lens of the present situation. This assists in making new interpretations that enable elaboration, further differentiation and re-enforcement of long-established frames of reference or to create new meaning schemes. In this sense, critical reflection is a major part in transformative learning that questions why we do what we are doing in problem-solving processes and validates whether our actions are thoughtful. According to Kitchenham (Kitchenham, 2008), the thoughtfulness of learners' decisions is related to Freire's three stages of critical consciousness growth, i.e. "intransitive thought," "semi-transitive thought" and "critical transitivity" (Freire, 1973).

The “intransitive thought” is the lowest stage of consciousness growth which occurs when people feel that their lives are out of their control and that change is left up to fate or God. The stage of “semi-transitive thought” involves some thought and action for change, but an individual at this stage addresses problems one at a time and as they occur rather than seeing the problem as one of society in general. The highest level of “critical transitivity” is reflected in individuals who think globally and critically about their present conditions and who decide to take action for change. These people are able to merge critical thought with critical action to effect change in their lives and to see what the catalyst for that change could be. This third stage of critical consciousness is the basis of Mezirow’s notions of disorienting dilemma, critical reflection, critical self-reflection on assumptions and critical discourse (Mezirow, 1978; Mezirow, 1985). McCormack (2009) noted that “*in their stories participants actively analyzed, evaluated and re-evaluated and through self-reflective dialog they recognized that emotions played a role in shaping their experience and its outcomes*” (McCormack, 2009). These elements are part of the pesticide delivery system of Ethiopia, which has been undergoing a continuous learning process in adopting new technologies supported by international and national regulatory frameworks, the mismatch in implementation when unintended results happen to emerge and when smallholder farmers become proactive with critical reflection on alternative pest management mechanisms and their application at local, regional and national levels.

The theory of perspective transformation – a paradigmatic shift – addresses a frame of reference with critical reflection on experience. According to Mezirow, a perspective transformation often occurs either through a series of cumulative transformed meaning schemes or as a result of an acute personal or social crisis which is stressful and painful with no apparent immediate solution (Mezirow, 1997). A perspective transformation has 10 steps, as follows: 1) A disorienting dilemma; 2) A self-examination with feelings of guilt or shame; 3) A critical assessment of epistemic, socio-cultural or psychic assumptions; 4) Recognition that one’s discontent and the process of transformation are shared and that others have negotiated a similar change; 5) Exploration of options for new roles, relationships and actions; 6) Planning of a course of action; 7) Acquisition of knowledge and skills for implementing one’s plans; 8) Provisional trying of new roles; 9) Building of competence and self-confidence in new roles and relationships; 10) A reintegration into one’s life on the basis of conditions dictated by one’s perspective (Mezirow, 1978). The result of this process is “more inclusive, differentiating, permeable, critically reflective and integrative of experience” (Mezirow, 1990). Individuals are thus more empowered, more independent, and more capable of taking charge of their lives. Tidbal et al., in their paper on stewardship, learning and memory in disaster resilience, indicated that ecology practices, including urban community forestry, community gardening, and other self-organized forms of stewardship of green spaces in cities, had been manifestations of how memories of the role of greening in healing could be instrumentalized through social learning to foster social-ecological system resilience following crises and disasters (Tidball et al., 2010). They called these actors civic ecology communities of practice and appreciated them for the collaborative and adaptive management practices that play a role in social-ecological system resilience. Examples of these communities of practices indicated in the paper included the Living Memorials Project in post-9/11 in New York City, and community forestry in New Orleans following Hurricane Katrina. They detailed their experiences as follows:

> The process begins immediately after a crisis, when a spontaneous and collective memorialization of lost ones through gardening and tree planting ensues, following which a community of practice emerges to act upon and apply these memories to social learning about greening practices. This in turn may lead to new kinds of learning, including about collective efficacy and ecosystem services production, through a kind of feedback between remembering, learning, and enhancing individual, social, and environmental well-being. This process, in the case of greening in cities, may confer social–ecological system resilience, through contributing to both psychological–social resistance and resilience and ecosystem benefits.

Such stewardship-based environmental actions can be taken as good lessons to deal with environmental and human health-related disasters through engaging all actors in the process in order to build stewardship behavior in the Ethiopian pesticide delivery system.

The transformative learning theory of Mezirow is guided by Habermas' (1984) concept of instrumental and communicative learning. Instrumental learning is related to learning how to manipulate and control the environment with a task-oriented approach of claiming the truth if something is what it is supposed to be (Habermas, 1984). Communicative learning on the other hand is based on understanding the meaning of what is communicated in relation to the assumptions, intentions, and qualifications of the person communicating. Moreover, critical reflection and critical self-reflection are important aspects of communicative learning, especially in understanding self-skills, sensitivities and insights with an open mind so as "*to arrive at the best judgment, not to assess the truth claim, as instrumental learning*" (Habermas, 1981).

The communication in communicative learning can be conveyed through dialogue, conversation, a book or an artwork. The intent, qualifications, truthfulness and authenticity of the one communicating is important to lead the learners to reach the best consensus-based judgments. The judgments will, however, remain tentative, leaving room for new evidence, arguments and perspectives. To reach the best consensus-based judgments and to critically reflect on those judgments based on new perspectives requires the full and free involvement of learners. In order that learners can participate in discourse fully and freely, Mezirow recommends that they must:

1. have accurate and complete information;
2. be free from coercion, distorting self-deception or immobilizing anxiety;
3. be open to alternative points of view – empathic, caring about how others think and feel, withholding judgment;
4. be able to understand, to weigh up evidence and to assess arguments objectively;
5. be able to become aware of the context of ideas and critically reflect on assumptions, including their own;
6. have equal opportunity to participate in the various roles of discourse;
7. have a test of validity until new perspectives, evidence or arguments are encountered and validated through discourse as yielding a better judgment.

This is evident in the case of this thesis, which involves multi-actors at the meta level of interaction, which incorporates experts, government officials, researchers, pesticide manufacturers, wholesalers and vendors and civil society interest groups trying to build a common sense of shared responsibility on pesticide risk communication.

Dirkx (2006) emphasizes enhancing the role of an individual transformative learner through a holistic approach so as to recognize the role of feelings, other ways of knowing and the role of relationships with others in the process of transformative learning. Dirkx argues that it is "about inviting 'the whole person' into the learning environment, the person in fullness of being: as an affective, intuitive, thinking, physical, spiritual self" (Dirkx, 2006). These holistic approaches include valuing the importance of relationships with others in fostering transformative learning and in developing essential relational qualities such as nonhierarchical status, non-evaluative feedback, voluntary participation, authenticity, and establishment of mutual goals. Yorks and Kasl (2002) also link phenomenon learning within relationships through a process in which individual learners become engaged with both their own whole-person knowing and the whole-person knowing of their fellow learners (Yorks and

Kasl, 2002). This creates grounds for emphatic connection, which establishes a group habit of being for the whole-person of learners to interact with others through the same balanced mix in ways of knowing through affective and imaginal modes of psyche, as well as conceptually and practically. This is also believed to reveal learners' feelings through active dialogue.

On the other hand, Mezirow's transformative learning is limited to individuals and Taylor (2008) brought an alternative conception of emancipatory transformative learning which is based on the work of Freire (1970). Emancipatory transformative learning is much imbedded in social, relational and political structures. This is more applicable to the resource-poor grassroots farmers to enable them to fully participate in their own development agenda through action and reflection. As emancipation, according to Freire is liberation, the active involvement of the individual as a whole learner and a whole actor in their development agenda leads to the required transformation (Freire, 1970; Taylor, 2008).

Knowledge production in the transformative learning process

In the transformative learning process, however, it is important to look into challenges in filling gaps between theory and practice, which is mainly related to the dissemination of evidence and its implementation. The implementation process is considered as more complicated than dissemination, because implementation is challenged by a complex situation of social, cultural and traditional settings (Glasgow and Emmons, 2007; Green et al., 2009). Van de Ven and Johnson also viewed these challenges in three ways: 1) problem of knowledge transfer; 2) utilization of knowledge from research and knowledge from practice as equally legitimate and 3) problem of knowledge production (Van de Ven, 2007, Van de Ven and Johnson, 2006). According to Hill (1998), *Knowledge is produced when people make sense of their world and knowledge is based on their experience as they construct tools, methods, and approaches to cope with the situations facing them* (Hill, 1998). The main questions to raise here are what kind of knowledge is produced? How is it perceived and used? Who considers it as knowledge? And what will be its implication to policy and development? In relation to this, Gibbons (2000) classified knowledge production into Mode 1 and Mode 2: In Mode 1, according to Gibbons, *problems set and solved in a context governed by interests of specific community in a disciplinary manner characterized by homogeneity of skills in hierarchical organizational structure*. In Mode 2, however, *knowledge is produced in a context of application involving broader range of perspectives, in a trans-disciplinary approach characterized by heterogeneity of skills in a flatter organizational structure* (Gibbons, 2000; Gibbons et al., 2000).

Mode 1 knowledge production, which is identical to “science”, has its social and cognitive norms that constitute “good science” and its disciplinary structure is usually applicable in universities (Gibbons, 2000). Other researchers also view Mode 1 as a linear approach that focuses on a one-way process of knowledge production by researchers to be disseminated to end users for incorporation into policy and practice. This linear model views knowledge as a product that moves through relatively discrete, predictable and manageable stages to reach users through effective one way communication. This linear process is a good choice for transforming policy to practice when the knowledge has a high relative advantage, low complexity, low risks and costs and if strong institutional structure and resources are in place to support the full production to application process and if the culture is supportive to practitioner behavior change (Best et al., 2008; Best and Holmes, 2010).

However, Mode 2 knowledge is generated within a context of application with socially distributed, application-oriented, trans-disciplinary and multiple accountabilities incorporating both experts and practitioners. The knowledge is embodied in the expertise of individual researchers and the research team so as to deal with a more complex, non-linear wicked problem (Nowotny et al., 2003). The research and knowledge production is therefore not limited to the field practices, but there will also be more knowledge production when a science-policy dialogue is undertaken (Sarewitz and Pielke, 2007).

Understanding the historical and cultural settings of Ethiopia, the importance of formal and informal education, the social hierarchy and its implications on the learning process as well as the political setting and implementation of international and national policies frame the way of applying the theories on the ground. Considering these settings, we will deal with transformative learning theory in relation to the modes of knowledge production as a means of explaining the process of transformation, questioning whether individual transformation results in group (societal) transformation and whether pockets of societal transformation can trigger a process of dialogue on national policy frameworks for policy transformation. Applications of both Mode 1 and Mode 2 knowledge are recommended based on the type of problem to be dealt with (Hisschemöller et al., 2001). Application of transformative learning in a non-Western setting is also reviewed, which can guide this study to consider the limitations of early applications of the theory (Merriam and Ntseane, 2008; Ntseane, 2012; Percy, 2005) to the Ethiopian situation.

4.3 Framing and Risk communication

Risk communication is defined and further explained by William Leiss as "the flow of information and risk evaluations back and forth between academic experts, regulatory practitioners, interest groups, and the general public". The sharp disagreements that can occur between members of these constituencies over the best ways to assess or manage risks are sometimes based on disagreements over principles or approaches, sometimes on differences in the information base available to various parties, and sometimes on a failure to consider carefully each other's position (Leiss, 1996). Cox also referred to Plough and Krimsky (1987) and defined risk communication as "any public or private communication that informs individuals about the existence, nature, form, severity or acceptability of risks" (Cox, 2010; Plough and Krimsky, 1987). Ulrich Beck's "Risk Society" presents the nature of risks and the threats that modernization brings to human life (Beck, 1992). The task of pesticide risk communication and risk reduction mainly depends on how individuals perceive various risks, what factors enter into the estimation of risk, and how people make risk-related choices. According to Tierney, particular emphasis is placed on the nature of human cognitive processes and on the manner in which the framing of risk estimates influence laypersons' responses to risk information. The main effect with this regard has been to make individual and group perceptions a central consideration in the dialogue about risk (Tierney, 1999). Breakwell also emphasizes that it is useful to know something about the basis for risk perception in order to understand the impact of risk communication (Breakwell, 2000). According to this literature, judgments about perceived risk and its acceptability are a function of: (i) a variety of qualitative aspects of the hazards, such as levels of perceived control and voluntariness, or catastrophic potential; and (ii) demographic characteristics, individual attitudes, or cultural and institutional affiliations. To maximize the impact of risk communication, the message must have a content that triggers attention, achieves comprehension and can influence decision making. It must be unambiguous, definitive and easily interpretable – rarely achievable particularly when risk is shrouded in scientific uncertainty. Audience perception of risk is influenced by demographic factors, personality profile, past experience, and ideological orientation (Breakwell, 2000).

Farmers' risk perception is directly related to their beliefs, attitudes, interpretations and judgments concerning the risk (Breakwell, 2000; Pidgeon, 1998). An individual's risk perception and risk-related choices depend on the understanding of risk information. Pesticides that can cause acute poisoning and result in sudden death are often perceived as highly toxic compared to those that have long-term chronic effects with minimal or no demonstrable instant symptoms. The framing of risk perception on the basis of mere visible effects of exposure to end users (Peres et al., 2006) requires an ethical approach from the pesticide industry, extension workers and others that are involved in the pesticide delivery system to share concerns about pesticide-related risks. Citizens' participation in risk communication (Cox, 2012) and recognizing cultural knowledge and the experience of local communities throughout the process of risk communication are also vital in bringing about the desired change of mitigating pesticide-related risks. Distorted risk perception that "no visible effect after exposure = no risk" should be handled carefully and communicated in such a manner that can effectively influence individual and group responses to risk information (Tierney, 1999).

The framing of the value and application of pesticides as part of the process of agriculture modernization is related mainly to high production and productivity. Governments and policy makers incorporate a high input policy; and the relationship of pesticides to productivity/economic growth has been conveyed to different levels. This could be explained by the cascade activation theory of Entman (2003) from agriculture ministries through extension agents, experts and media to grassroots pesticide end user farmers (Entman, 2003). Pesticide use also demonstrates high productivity until the soil tires and the pesticide treadmill appears with its environmental and human health impacts (Sherwood, 2009). Even with the demonstrable evidence of the human health and environmental impacts of pesticides, the first perception of productivity-related experience dominates pesticide risk perception. The policy level action to mitigate pesticide impacts could be achieved through an active reframing of pesticide policy issues that also include pesticide risks and the meaning of ethical and responsible use. With a political will and bringing all actors on board, the pesticide policy issue would be reframed (van Hulst and Yanow, 2016) through an interactional co-construction (Dewulf et al., 2009) approach of actors with divergent interests. This process, however, requires epidemiological and public health-related studies and evidence to which I will refer later.

Reframing of pesticide risk at grassroots level should, however, consider farmers' cognitive representation (Dewulf et al., 2009) of pesticides, which is an embedded knowledge based on their past experience with regard to pesticide use. The most common understanding has been relating pesticide use to high productivity/gain; and reduced/no-use to less productivity/loss. This understanding underplays the human health and environmental impacts of pesticides. Once the situation has been widely accepted with the original framing, coming up with conflicting information and abruptly trying to communicate this results in failure to be understood and accepted. Entman (1993) describes this situation by saying that *the power of a frame* *can be as great as that of language itself* (Entman, 1993). There should, therefore, be a systematic way of approaching reframing. An action-oriented communicative learning that is able to weigh the framed benefit and uncover the hidden unplanned side-effect, as well as initiate dialogue (with those that have been affected) to reframe or counter-frame the unframed or mis-framed situation is required.

The dialogue of reframing is enhanced when supported by evidence of the actual impacts of the original framed situation. In order to reveal evidence about the actual impacts of pesticides and risk perception of farmers, two models of risk communication indicated by Cox could be used in the process of a research that envisions bringing about policy change. These models are a technical model of risk communication which deals with translating numerical assessments of pesticide risks to farmers; and a cultural model of risk communication which revitalizes the local knowledge of affected farmers together with a laboratory model of risk assessment (Cox, 2012). In line with this, Arcury et al. (2000), in their community-based risk assessment research, emphasized two major areas that need development for community-based research on farm worker pesticide exposure. The first area is conducting rigorous epidemiological and survey research that produces generalizable results. The authors indicated that depending only on case-study analyses to remediate the risks of pesticide exposure in the population and to influence environmental and occupational regulations would not work. Their second recommendation is developing procedures to measure biological exposure to pesticides among farm workers (Arcury et al., 2000). This, they claim, would develop community-based fact finding which involves the community in working with the researchers. This process, however, needs the involvement of both affecting and affected actors so as to bridge the research to the desired change with the full involvement of actors in the process. The risk assessment data which is prepared under the contexts of developed countries (in the laboratory) with the consideration of "a Caucasian healthy male" as a reference to relate human pesticide exposure lacks consideration of tropical environments, non-Caucasian men and women, children and unhealthy applicators, which is actually the case in Africa. The development of risk assessment data and the approach of risk communication in developing countries is mostly blamed for not involving affected communities/the target audience (Rother, 2008; Rother, 2010; Rother, 2011a) which is considered as the main cause for not bringing about the required change. Networking of people and interaction among organizations (Sherwood, 2009) could be one approach to create a space for dialogue towards the change process.

Risk communication can be taken up in a variety of ways, to cater to the divergent interests of different groups. The three main ways that risk communication can be used differently, according to Rother (2011) are: (1) risk communication as public relations (i.e. educating the public); (2) risk communication as a business strategy (i.e. regulatory compliance, risk sharing, transferring liability to end users as is the case with pesticide labels where the end user may have to pay a penalty/be imprisoned for not using a pesticide as directed on the label), and (3) risk communication as risk management (i.e. eliciting safety behaviors). The objectives and goal of communicating risks vary, overlap, and sometimes even conflict within these three approaches. Rother further explains the different connotations of risk communication, as for example; the view that risk communication as a business strategy (2) would focus on the ultimate goal of fostering corporate profits rather than the promotion of human health, which would be the primary focus in risk communication as a risk management strategy (3). All three strategies are used in communicating risks about pesticides to workers, end users and the general public. However, the purpose of the strategy depends on who is communicating and what their underlying goal or purpose is (Rother, 2011a). The main reason for creating a space for dialogue amongst all actors in the PDS is to bridge these gaps so as to come up with a common understanding of the existence of adverse impacts to human health and the environment from pesticides, and understanding how to mitigate these risks.

4.4 Institutional Innovation

There have been many attempts to create sustainable smallholder agriculture in Africa. Technology development and local capacity building have been among these attempts, however they were not able to succeed because of institutional constraints (Hounkonnou et al., 2012; Röling, 2010). Institutions reflect the conventions that have evolved in different societies regarding the behavior of individuals and groups relative to their own behavior and the behavior of others (Ruttan and Hayami, 1984). Stable institutions provide assurance, respecting the actions of others, and give order and stability to expectations in the complex and uncertain relations. The development process, therefore, requires institutional learning which creates space for communication and interaction among actors to question, reassess and reformulate the development agenda according to the local situation. This process in turn creates a common understanding and shared codes of conduct that lead to meaningful collective action. The process of negotiation and interaction among key actors which facilitates learning around concerted action to change institutional conditions and/or create new opportunities is termed *institutional innovation* (Röling et al., 2014). Institutional innovation can support other forms of innovation (technological or knowledge) through changing the rules of a society or of organizations that facilitate coordination among people by helping them form expectations which each person can reasonably hold in dealing with others.

Innovation platforms with diversified interest of members provide access to distributed knowledge and resources, thereby enhancing learning, integrative negotiation of interest and mobilization for change (Leeuwis et al., 2004; Van Bommel et al., 2009). Multi-actor forum negotiation which entails divergent interest of actors requires the participation of all actors in the decision-making process. However, the predetermination of policies of interest by the government which marginalizes major non-state actors, unbalanced power relations in the dialogue process, the emergence of unplanned outcomes, a time-consuming dialogue process and the complexity and unpredictability of results are amongst the main factors that are indicated in different studies to be responsible for the failure of participation in the innovation processes (Aarts and Leeuwis, 2010; Aarts et al., 2007; Cleaver and Toner, 2006; Turnhout et al., 2010; Van Bommel et al., 2009; Biggs, 2007; Röling et al., 2014). Sustaining institutional platforms that overcome these challenges of participation and action in the innovation processes is another aspect that should be investigated. Some agricultural development-based innovations that are donor-funded/project-based have failed to sustain themselves while others have succeeded (Biggs, 2007; Röling et al., 2014).

Innovation intermediaries/brokers who act as connecting bridges between different stakeholders, their interests and institutions are main actors that maintain the momentum of the interaction process (Klerkx et al., 2009). The agriculture extension systems through the extension agents had been traditional intermediaries in supporting agricultural innovation, particularly in transferring technology and knowledge to farmers. However, Kilelu et al. (2011) argue that the effectiveness of this approach has been questioned for its linearity and recommend broad systemic support beyond knowledge generation and use, including the forging of links and interactions among diverse actors (Kilelu et al., 2011), while others argue that supporting innovation goes beyond increasing the supply of new scientific knowledge and technologies; rather it emerges out of the interplay between scientific, technological, socio-economic, institutional and organizational arrangements (Smits, 2002). These organizations undertake a range of activities that include: scouting potential collaborators; brokering a transaction; mediating, helping find advice, funding and supporting collaboration. Klerkx and Leeuwis (2008) also indicate that there is a distinction between actors who take on intermediary roles but contribute substantive knowledge to the innovation process (i.e. as an expert or translator of research findings); and those who are specialized innovation intermediaries and act as enablers by facilitating multi-stakeholder interactions in innovation (Klerkx and Leeuwis, 2008).

Rutan and Hayami (1984) divide innovations between those that are embodied in capital goods or products and those that are not embodied in any physical item. Tractors, new seed varieties and new types of pesticide or fertiliser are all examples of embodied innovations. A new formula to improve irrigation scheduling is a disembodied innovation. Moreover, the authors emphasize that the innovation process may result in new products, yield-increase, cost reduction, enhancement of product quality and protection of human health and the environment. They also note that the development of technologies that improve environmental quality or at least reduce damages relative to existing technologies is becoming a major research and policy priority (Ruttan and Hayami, 1984). Thus, the growing interest in innovations that enhance the viability of "green technologies" such as biological control or organic farming has been given emphasis (Sunding and Zilberman, 2001). Ceess Leeuwis also argues that change agents should not limit innovation only in terms of 'transferring technology' or 'diffusing' a readymade innovation. He rather suggests the need to think about it in terms of a process that takes place in the context of the building, design and/or evolution of effectively re-ordered relations between 'hardware, software and orgware'. He emphasizes the role of communication in the innovation process and he terms this communication *communicative intervention*. In the process of communicative intervention, he argues about the need for simultaneous processes of network building, supporting social learning and dealing with power conflicts (Leeuwis, 2010). Realization of these complex processes is vital when dealing with a network of actors with varying interests such as the PDS in Ethiopia.

Innovation is understood us an "emergent process of production of new social arrangements, new symbolic practices and new materialities" (Suchman, 2002) which has been evident with different socio-political settings and a diversity of actors. Innovation platforms are configurations of social networks and institutional arrangements that enable institutional change (Ayre et al., 2014). Innovation platforms in this thesis are seen as support for agricultural institutional innovation which facilitates technological, social and economic change through the notion of an ethic of pesticide stewardship as a guiding principle to all actors in the PDS. The pesticide users' stewardship is a problem-driven (Van Paassen et al., 2014) initiative at national and grassroots local level in the Ethiopian PDS. The focus has been on participatory dialogue, appreciating pesticides and pesticide-related policies as part of the national development process and bringing different angles of looking at them from human health and environment perspectives. The dialogue started by appreciating the benefits of pesticides in agricultural modernisation in Ethiopia and presenting its unplanned side-effects, which required participatory policy formulation (Aarts and Leeuwis, 2010) as the point of departure at federal, regional and local level in the PDS. This process also noted the unpredictability of the success of innovation platforms and came across experiences of weak innovation systems in some developing countries (Szogs, 2008) so as not to risk repeating the same mistake. Successful experiences were also assessed and lessons were learnt regarding how they strengthen innovation platforms with active intermediary organizations that create necessary linkages between different actors (Klerkx et al., 2009; Klerkx and Leeuwis, 2008).

5 Methodology

Participatory action research was followed as the main research philosophy and methodology in order to bridge the gap among actors in the PDS of Ethiopia and to create a common forum for communication. Participatory action research methodology follows the cyclic process of planning, taking action and evaluation of the actions, which leads to further planning and more iterations of the cycle (Brannick and Coghlan, 2010). In addition to bringing about change on the ground, the systemic action research process results in learning through reflection at different levels, within and among the institutions and individuals involved in the research process (Arévalo et al., 2010; Packham and Sriskandarajah, 2005). When participatory action research is a community- based approach, it facilitates learning and the production of knowledge through a trans-disciplinary collaboration of actors in the learning process (Smith et al., 2010).

For an action research to happen in the development process, certain requirements have to be fulfilled and be fully functional. Grundy (1982) sets three minimum requirements to be fulfilled so as to take a process as action research. These requirements are 1) taking a social practice as a subject matter susceptible to improvement; 2) the process to proceed a spiral of cycles of planning, acting, observing and reflecting, with each of the activities being systematically and self-critically implemented and interrelated and 3) involving those responsible for the practice in each of the moments of the activity, gradually widening participation to include those affected by maintaining collaborative control of the process (Grundy, 1982)

This thesis was, therefore, guided by the main principles of action research. National level dialogues incorporating actors from all levels of the PDS have been conducted with a focus on system-wide pesticide users' stewardship with reiteration of the action research cycle in the process. Within the overarching goal of pesticide users' stewardship, there have been federal level policy-related dialogue, regional level pesticide risk communication-related dialogue and local level action-oriented IPM-FFS. All these process also plan, act and reflect and reiterate the process with a mix of Mode 1 and Mode 2 knowledge production that has contributed to the wider pesticide users' stewardship goal. Figure 2 shows the conceptual framework of the action research process.

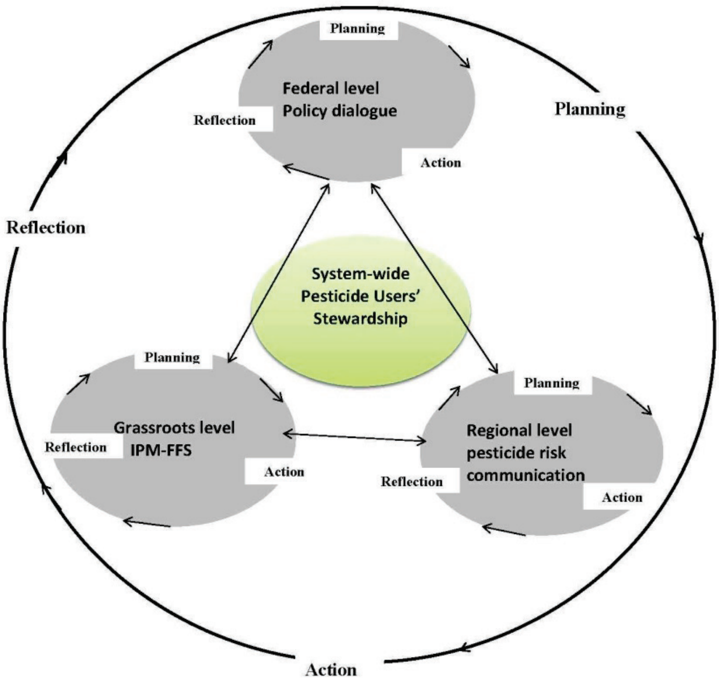

Figure 2. Action research cycle of the pesticide stewardship dialogue.

Taking participatory action research as a guiding philosophy, combined methods of qualitative and quantitative as well as experimental methods were used in order to address the research questions, which range from high level policy to grassroots action.

5.1 Qualitative and quantitative methods

For the questionnaire-based survey, quantitative and qualitative methods of data collection were used to gather information from farmers and agriculture experts.

For the quantitative study, a semi-structured, interviewer-administered questionnaire was used to collect information on the socio-demography of households, pesticide practice, and pesticide knowledge and risk perception. The questionnaire was developed in English, translated into local languages for the purposes of administration, and the scoring was translated back into English for data entry. The questionnaire was pre-tested for clarity and corrected for accuracy with farmers who lived in the study areas but did not participate in the study. The data collection was assisted by trained high school graduates, university students and local agriculture and health office workers.

For the qualitative part of the data collection, farmers were asked open ended questions and additional observations were made in the field by the first author as primary researcher. Pesticide poisoning cases reported by interviewees were recorded and compiled separately. Specific case stories were recorded by the researcher while farmers were carrying out their routine farming activities.

Moreover ,focus group discussion questions were prepared to obtain an insight into the essence of the relevant systems of the PDS in Ethiopia, to identify the weak link where risk perception of farmers deviates from the actual impact pesticides bring to human health; and to assess the challenges of the extension system in mitigating the problem. Checkland's Soft Systems Methodology was used to frame the group discussion (Checkland and Haynes, 1994). The focus group discussion questions focused on identifying the system's beneficiaries (Customers), the actors who are deemed relevant in transforming the current situation to where it ought to be (Actors), the process that leads to the desired situation (Transformation), the relevant world views in the system (Weltanschauung), those who have power to influence the transformation (Owners) and the environmental constraints that need to be considered in the transformation process (Environmental constraints) – which Checkland abbreviates as CATWOE. Using the CATWOE checklist, a focus group discussion was conducted among 28 regional agriculture bureau experts and 22 district extension agents selected by the Ministry of Agriculture from all the Ethiopian regions.

Random sampling was employed to select villages and households participating in the questionnaire-based survey data collection. The selected villages were contacted through a formal letter written from the local agriculture offices. Data was collected after obtaining full verbal consent from farmers and the confidentiality of participants was maintained, with no names being disclosed through any means of communication. The source population only included farming households in the study districts. The number of farmer participants included in the studies was determined using a single population proportion formula (Yamane, 1967).

5.2 Workshops

Participatory workshops were used as the main method of contributing as well as enacting the network at different levels of the PDS and as the essential activity for PSA to be functionally realised. Policy level dialogue workshops were held in 2011 and 2014 with the active involvement of the Ministry of Agriculture (MoA) of Ethiopia, the Environmental Protection Authority (EPA) of Ethiopia, the Desert Locust Control Organization for Eastern Africa (DLCO-EA), Crop Life Ethiopia, National Universities and research institutions, the media, NGOs, the United States Agency for International Development (USAID), the United States Department of Agriculture (USDA) and the Swedish University of Agricultural Sciences (SLU); the latter two were involved as part of the PhD study team. These two policy level (meta level) workshops were followed by regional (meso) and local (micro) level workshops incorporating all the above actors together with local authorities and farmers. The empirical work on participatory workshops conducted amongst all actors in the PDS, the processes underwent and consensuses reached at policymaker and grassroots level were recorded. The detailed process of a pesticide stewardship network inception workshop and reflection of actors on the gaps in the PDS, pesticide stewardship association workshops and follow-up linkages indicated in Table 6 are also reflected in detail in Paper II.

Table 6. Summary of participatory workshops

No.	Event	Location and date	Participants	Intended purpose	outcome	Follow-up events
1	PSN Inception workshop	Aug.23-27, 2009; Nazareth, Ethiopia	MoA, EPA, DLCO-EA, Croplife, Universities, Research Institutions, Media, NGOs, USAID	-Initiating participatory dialogue among actors in the PDS	-Felt need for networking	Establishment of PSA
2	PSA workshop	July 25-26, 2011; Nazareth, Ethiopia	All indicated above and SLU	Policy level dialogue for institutional change	Collaboration of actors in the PDS to mitigate pesticide impacts	Policy level and grassroots actions
3	Pesticide risk reduction & Risk communication workshop	July 27, 2011; Ziway, Ethiopia	All in No. 2, local government representative, district advisors, flower farms and small holder farmers	Pesticide risk mitigation	Risk communication dialogue started	Risk communication trainings and vegetable IPM
4	Cotton IPM-FFS workshop	July 29, 2011; Arba Minch, Ethiopia	All in No.2, local gov't, district advisors and cotton farmers	Promoting IPM-FFS as a means to mitigate pesticide impacts	Farmers engaged in IPM-FFS	Sustainable cotton and organic cotton production underway
	Cotton IPM-FFS first year evaluation workshop	October 16-17, 2013	MoA, EPA, DLCO-EA, Croplife, Universities, Research Institutions, Media, NGOs, local and regional government	Presentation of farmers' experiences of the 2013 cotton production season and assess what went well and what should be improved for the next production season	Successes, challenges and corrective measures for the 2014 production season documented	Strengths of the 2013 maintained and corrective measures taken for the 2014 production season
	A workshop discussing cotton IPM-FFS as one means leading towards pesticide users' stewardship	July 1-3, 2014	MoA, EPA, DLCO-EA, Croplife, Universities, Research Institutions, Media, NGOs, USAID and SLU	Discussion on the Human, social and communicative aspects of the project	Farmers' deep understanding and their experiential learning skills revealed	Farmers' field day preparation agreed to be organized
	Farmers' field day	October 2-3, 2014	MoA, EPA, DLCO-EA, Croplife, Universities, Research Institutions, Media, NGOs, local and regional government	Farmers presented about the preparation and application of food spray as well as about their experiential learning practices in plant protection, agronomic and health related sessions at their weekly FFS	The Zonal administration appreciated the results and outcomes and pledged to support the expansion of the wok in neighbouring districts	Expansion proposal is developed and on the way to be submitted to donors

5.3 Experimentation

Cotton is considered a high value cash crop, but the high costs of production have had a significant impact on its profitability. The cost of inputs such as pesticides and fertilizers is very high and has become a significant burden to many smallholder cotton farming families (PAN-UK, 2009). Considering the ethical value of reducing the negative impacts of pesticides on human health and the environment from production of cotton with environmentally friendly natural methods is attracting attention at present following some positive results in the development of alternative pest management options with the use of semiochemicals and biopesticides (Mensah et al., 2013b). The development of alternative pest management options such as the use of supplementary food spray products to help boost the abundance of beneficial insects and spiders can contribute to an increase in organic cotton production (Mensah et al., 2012). An experimental design was therefore prepared and followed for two consecutive years (2013 and 2014) so as to develop a locally adoptable and effective food spray that could be utilized by cotton farmers in the southern Ethiopian Rift Valley.

Two different types of food spray product, namely Benin food product (BFP) (Mensah et al., 2012) and Ethiopian food product (EFP) were used in the study. Both BFP and EFP were prepared using local ingredients and were used as individual treatments. The main ingredient of BFP is coarsely ground maize seeds while for EFP it is a liquid form of brewer's yeast *(Saccharomyces cerevisiae)* obtained from a commercial beer brewing enterprise. Extract from powdered neem seeds (*Azadirachta indica)*, was mixed with BFP and EFP to create additional treatments. The BFP was used as a benchmark for assessing the effect of EFP on the populations of pests and beneficial insects in cotton crops, as per Mensah et al., 2012.

The experiment was conducted with smallholder farmers on their cotton fields in the Shelle Mella, Chano Mille and Faragossa villages of Gamo Gofa Zone in the Southern Nations Nationalities and Peoples Region (SNNPR) of the Southern Ethiopian Rift Valley area. The soil in Shelle Mella is black-loamy clay; Chano Mille has sandy clay loam and Faragossa has a sandy loam soil.

Each field for the treatment plots was given a pre-treatment application of dry cow manure at the rate of 2,400 kg/ha before the cotton seed was planted. The cotton variety used for the study in all the study sites was Deltapine (DP) 90, a widely used variety in the Ethiopian cotton industry. The DP 90 cotton seeds were provided by the Cotton Research Institute in Melka Werer in Ethiopia. The fields were planted on 29 May 2013 in Shelle Mella, 30 May 2013 in Chano Mille and 13 June 2013 in Faragossa. The study was repeated in 2014 at the same sites, using the same cotton varieties and land preparations.

In both the 2013 and 2014 studies, six treatments were set. These were (1) 4 kg/ha Benin food product (BFP), (2) 4 kg/ha BFP + 4 L/ha Neem extract, (3) 4 L/ha Ethiopian Food product (EFP), (4) 4 L/ha EFP + 4 L/ha Neem extract, (5) 4 L/ha Neem extract alone and (6) Unsprayed (control). The plots were arranged in a randomized complete block design with three replicates. The replicated plots measured 40.5 m^2 at Shelle Mella; 120.3 m^2 at Chano Mille and 158.7 m^2 at Faragossa. A 5m wide buffer of 5 rows of maize was planted to separate the replicates of the treatments at all study sites. Unsprayed plots were used as the control, but were randomized within the treatments rather than being located away from the sprayed plots. Hence, there was no buffer to prevent the volatiles from the food spray treated plots drifting onto the unsprayed plots. However, a 60-m wide buffer of maize crop separated the experimental field from the adjacent cotton crops.

Foliar application of each treatment in 2013 was made on 6 and 25 July, and 4 and 23 September 2013 in Shelle Mella; 4 August and 1 September in Chano Mille and 3, 15 and 31 August and 24 September 2013 at Faragossa. In 2014, the individual treatments were applied on 25 May and 24 July at Shella Mella; and on 13 June, 1 and 25 July 2014 at Chano Mille. No sprayed treatments were applied at Faragossa in 2014 as a result of severe drought, which destroyed most of the plants and caused the trials to be abandoned.

The decision to apply the treatments was made based on a predator-to-pest ratio of 0.5 per metre (Mensah, 2002). In all, 4, 2 and 4 applications of each treatment were made in Shella Mella, Chano Mille and Faragossa respectively in 2013 and 2, 2 and 0 in Shella Mella, Chano Mille and Faragossa respectively in 2014.

Visual counts of pests and beneficial insects (mainly predatory insects) were made 24 hours prior to treatment application. Post-treatment counts of pest and predatory insects in 2013 were made at Shelle Mella from 16 July until 5 October 2013; Chano Mille from 26 July until 24 October 2013; and Faragossa from 1 August until 22 October 2013. In 2014, pests and beneficial insect counts were made visually from 15 May until 28 August at Shella Mella; 3 June until 16 September in Chano Mille and no counts were made at Faragossa as a result of crop devastation by drought.

The pest and predatory insect populations were sampled visually by examining whole cotton plants in three randomly selected 1m lengths of rows of cotton plants giving an average of 5 plants per metre in each treatment replicate; a total sample length of 3m per treatment. The data for individual and total number of pests and predatory insect species were expressed as numbers per metre for each sampling date. When the cotton crops had matured in each treated plot, including the unsprayed plot (control), they were harvested separately by hand and the average seed cotton yields (kg/ha) were compared between treatments.

In 2013, the cost effectiveness of managing pests and beneficial insects on cotton crops using food spray products meant we only harvested the seed cotton from the food spray plots in Shelle Mella trial site and compared the cotton yields and net margins with conventional insecticide treated plots. The reason for using the Shella Mella trial site only for comparison with synthetic insecticide treated cotton crops in the 2013 study was that it was the only study site that had conventional insecticide-treated cotton crops of the same variety (DP 90) which were also sown on approximately the same date as the food sprayed plots. The conventional cotton plot was located 400 metres away from the Shelle Mella trial site in the same agro-ecological area. The agronomic management of the conventional cotton fields was the same as that used for the food-spray treated plots, except that there was an application of foliar fertilizer and the pest control regime used synthetic insecticide in the conventional field. No pest abundance records were taken from the conventional insecticide treated plots, but the seed cotton was harvested at the same period as the food sprayed plots. No conventionally managed cotton crops that had used insecticides were located near the Chano Mille and Faragossa study sites; hence yields from these sites were not used in the net margin assessments.

In 2014, the cost effectiveness of the food sprayed relative to unsprayed (control) was determined for all study sites and was based on seed cotton yields per hectare, costs of food products, neem extract and spray application costs. The net margin assessment was based on cotton yields (kg/ha), cost of fertilizer and pesticide including the food products and neem extract, and spray application costs. Standard farm management costs such as seeds and weed control were excluded.

5.4 Farmer field schools

Farmer Field Schools

Farmer field schools were demonstrated to be effective in reducing pesticide dependency in order to protect human health and the environment and also to increase productivity by enabling farmers to follow their farms regularly and act accordingly (Mancini et al., 2007). Moreover, farmer field schools created strengthened social relationships through experiential learning, (Kolb and Kolb, 2012) which gives a chance for farmers to take participatory actions and have dialogues about their pest problems and on how to solve them. The top-down approach of conventional plant protection left a space for a consultative approach which enabled farmers to present their indigenous knowledge as part of the solution, to listen and try newly introduced techniques and explain what worked and did not work well. FFS are also means of addressing pest management problems by empowering famers to be experts of their own farms and as a main part of the process from pest management planning to decision making. Good practices in Asia in the 1980s and 1990s (Kenmore, 1996; Untung, 1996) were adopted in West Africa in 1995 (Simpson and Owens, 2002) and in East Africa in 1999 (Davis et al., 2012). All these experiences show that FFS could be a mechanism to convey IPM techniques which can enable farmers to use their indigenous knowledge, to adopt new alternatives and to consider pesticides as a last resort of pest management options in the crop production system.

Farmer Field Schools and experiential learning

FFS are also good examples of collaborative learning between scientists, experts and farmers in which a common platform of participatory action research which empowers farmers is undertaken. This process is mainly based on experiential learning (Kolb, 1984) that follows the cyclical process of experience leading to reflection which in turn leads to conceptualization and application (action), and reiteration of the cycle. According to Percy (2005), experiential learning is influenced by first and second order experiences, reflection and dialogue. First order learning in the case of farmers engaged in FFS are past lived experiences, either conventional pesticide use as in the case of Ethiopia (Amera et al., 2015) or traditional indigenous knowledge that could be incomplete, inadequate, or distorted. The second order experience follows when the existing knowledge is reconsidered for modification. As a complementary process towards action, reflection at different levels creates a path for dialogue amongst farmers, researchers, experts and policy makers. When reflection occurs at a higher level, it lays a foundation for transformation and empowerment (Percy, 2005; Röling and Van De Fliert, 1994). However, according to Franz (2002), transformative learning will be successful with strong partner facilitation and critical reflection in transforming partnerships in the presence of critical events (Franz, 2002); and a fundamental difference between partners bridged by a common purpose and the retention of personal autonomy along with dependence on the other partners. In the case of the Ethiopian PDS, the common understanding of the existence of human health and environmental impacts of pesticides in Ethiopian agriculture became a critical event which brought all actors with varying interests together for a common purpose. This initiated higher level reflection at PSA for proper action on the ground.

Farmer-to-farmer communication
Farmer field schools are appreciated for empowering farmers with better communication skills and increased social capital as a means to collective action (David, 2007, Mancini et al., 2007; Tripp et al., 2005). This enables farmers to conduct agro-ecosystem analysis through close observation of their farms in groups that strengthen the group learning process and group dynamic exercises giving them the opportunity to develop their communication skills. In addition to regular FFS sessions, the daily information flow and farmer-to-farmer communication during social interactions is one mechanism of disseminating IPM techniques to reach out to a wider community. The confidence farmers develop during their weekly sessions enables them to disseminate the knowledge they acquire and farmer-to-farmer communications reach more farmers than regular sessions. However, scaling up of FFS is usually considered the main challenge (Feder et al., 2004; Quizon et al., 2001)

Setting up farmer field schools
Farmer field schools were set up in three villages – Shelle Mella, Chano Mille and Faragossa – of the Gamo Gofa Zone in the Southern Nations Nationalities and Peoples Region of Ethiopia. A maximum of 25-30 cotton growing farmers in each FFS site of the three villages were arranged in groups of five to six members per group with one lead farmer. There were also facilitators following up and helping the farmers. Farmer field school sessions were conducted once a week for three hours. The FFS days and duration were decided by the farmers themselves. Adjustment of the training program, introduction to the IPM-FFS materials, group formation and other issues were discussed in the introductory meeting session of the FFS. The schedule was flexible and was open for rescheduling depending on other socio-economic and political commitments. The farmers in each group were active participants in cotton field observation and data collection. Farmers who were able to read and write took notes and those who were illiterate took part by recounting what they saw so that the information could be recorded. The farmers collected both plant protection and agronomic data. Records of plant protection data included pests of different types, natural enemies, diseases and other beneficial insects.

The FFS research process was guided by participatory action research (Dick, 1997). Participatory action research was taken as the main philosophy and methodology to reveal the actual results of local grassroots actions that had emerged as the result of higher level policy dialogues in Ethiopia since 2011. Participatory workshops at different levels of the PDS, a baseline survey before setting up FFS, and FFS as a participatory method of learning, technology development and dissemination based on experiential learning (Davis et al., 2012) were used as methods of qualitative and quantitative data collection.

Prior to the establishment of FFS, a semi-structured questionnaire was used to collect qualitative and quantitative data from 107 farmers in Shelle Mella, Chano Mille and Faragossa villages in January & February 2013. A total of 80 (74.76%) men and 27 (25.24%) women participated in the baseline survey just before the setting up of the FFS.

Experiments on food spray had also been going on in the process of the FFS, and insect scouting by beat sheet counting was being conducted once a week to ascertain the ratio of natural enemies and pests. Rows of cotton plants were randomly selected for the beating and a one meter long stick was used for beating. A One meter by 50 cm white sheet was also used for counting the falling insects during beating of the cotton plants. After beating the cotton plants with the one meter long stick, pests and natural enemies that fell on the sheet and flew around were counted. The use of “maize seeds” and “stones” as a decision-making protocol was agreed so that farmers used “maize seeds” to represent the number of beneficial or good insects and “stones” to represent the number of pests during their visual checks. Thus, for every beneficial insect on the crop, the grower would keep a “maize seed” and for every pest the grower would keep a “stone”. After sampling three 1m-long sections of the cotton crop on the farm, all of the kept maize seeds and stones were counted to determine the number of beneficial insects and pests on the crop. If the number of “maize seeds” exceeded the number of “stones”, then the beneficial insects outnumbered the pests and the grower would not need to control the pests. However, if “stones” outnumbered “maize seeds” by more than a factor of two, then the grower should control pests using a food spray mixed with soap. In a situation where the number of maize seeds is exactly half that of the stones, then the farmer should not treat the crops but should re-check the crop within three days to make a final decision.

Agronomic data such as the need for weeding, irrigation digging and thinning were also collected. After the observation and data collection, the farmers discussed in their groups to come up with an agreed decision to recommend what had to be done on the farm in the coming days/weeks. Each FFS group came up with respective recommendations justifying their respective observation and the owner of the farm would be advised to act on the whole groups’ agreed recommendations.

All participants would then go back and do the same on their own field for a week and also disseminate the knowledge to neighbouring farmers who did not participate at the regular FFS sessions. If a farmer faces a problem that he has not experienced in the regular FFS sessions, he/she would bring the issue to the weekly FFS session and make it a discussion point.

5.5 Data processing and analysis

Quantitative data from the surveys were entered into Epidemiological Information (EP Info) software version 6 and data analysis was conducted with Statistical Package for Social Sciences (SPSS) software version 11 for Windows. Frequency distribution and percentages were used to describe the quantitative findings. Qualitative data from observations and case stories and focus group discussions were analyzed by categorizing insights and replies to issues raised in specific discussions, and were compiled separately.

Quantitative data from the experimental designs of food spray treatments were analyzed using InStat Analytical Software version 3.0 (Graphpad Software, La Jolla, CA, USA). Treatments were taken as independent variables. All data were subjected to repeated measures of ANOVA followed by Tukey-Kramer Multiple Comparison tests to separate the means.

5.6 Methodological reflection

McNiff and Whitehead (2010) stated that the idea of influence is at the heart of action research and because action research is always conducted with other people who constitute social situations, and because those other people can think for themselves, the way to influence the trajectories of social change is to encourage them to act differently, through influencing their thinking (McNiff, 2010). This thesis had potential influence from my positionality on the steering committee of PSA, as a director of PAN-Ethiopia and moreover as a PhD student fully engaged in the action research process. My research was not a full insider research monitoring my own organization, which had been a challenge for researchers (Moore, 2007). It was a study looking at a bigger multi-level network which encompassed smaller but stronger institutions under it where I had access at all levels. This role of mine is the reason to consider the need to clarify my positionality, in order to maintain an ethical stance in the participatory action research process (Sultana, 2007).

In order to minimize desirability bias in the process of establishment of PSA and during workshops at the meta, meso and micro levels, PhD supervisors from Ethiopia, Sweden and the USA took part and the milestones were also validated with members of PSA. Their active engagement assisted me in being part of the process when my input was needed and in stepping back and reflecting on my personal workshop notes.

Data collectors were employed during baseline surveys conducted in the central and southern Ethiopian Rift Valley areas and supported by the close supervision of the federal ministry of agriculture and local agriculture office representatives. Study participants were requested for informed consent with formal letters and their names have not been mentioned in any communication or in this thesis.

For the implementation of IPM-FFS, an agreement was signed between PAN-Ethiopia and the zonal agriculture and finance and economic development department which bridged the action to be implemented at grassroots level. In order to avoid desirability bias during weekly FFS sessions, community dialogues and IPM-FFS work, two full time agronomists were employed to collect information and document the weekly data in logbooks. The data were verified by zonal agriculture extension agents and four experts of the Arba Minch plant health clinic.

6 Findings

The four manuscripts outline the existing situation of pesticide use in Ethiopian agriculture and elaborate the pesticide risk perception of farmers and the underlying communicative, policy, structural/institutional and economic reasons presented by experts as justification for what is happening in the sector. The PhD research process created a dialogue forum which discussed the need for system-wide pesticide users' stewardship as a means to mitigate the environmental and human health impacts of pesticides without compromising production and productivity. This dialogue process was undertaken at three levels, namely at the national level as a policy dialogue, at the regional or middle level in terms of understanding pesticide risk perception/risk communication, and at the very local level in moving towards implementation of action-oriented smallholder farmers-based IPM-FFS. On reflection, the three levels at which the dialogue process was undertaken have been identified as the macro, meso and micro levels for convenience of description.

The presentation of the findings in this chapter is arranged in such a way to avoid unnecessary repetition of what has been dealt with in the four manuscripts. Instead, the main processes that served as an umbrella for the overall project and the findings that emerged from the action researching cycles at that level are dealt with here.

6.1 The initiation of Pesticide Stewardship in Ethiopian Agriculture

This section covers how the concept of pesticide stewardship emerged in discussions and the processes it went through in the five year period of 2009-2014. As I have been involved in the process from the very beginning and as "stewardship" was a new approach for most of us, I am motivated to document the entire process which later became part of my dissertation.

6.1.1 The first Pesticide Stewardship Initiative

With an appreciation of pesticide problems in Ethiopian Agriculture, MoA, DLCO-EA, USAID and USDA took an initiative to create a dialogue forum among actors on how to deal with the problem. The first planning workshop was conducted in 2008 to discuss pesticide problems in the Ethiopian agriculture sector and to identify the main actors in the pesticide delivery system (PDS) in Ethiopia. The pesticide problems discussed touched on the entire range of actors in the pesticide delivery system and revealed the lack of a concerted effort to mitigate it. In order to have a proper discussion among actors in the PDS, a committee involving representatives from government, NGOs, Universities and the private sector was established. As a representative of civil society organisations, I was elected to be the secretary of the planning committee. The committee was led by the Ministry of Agriculture of Ethiopia and DLCO-EA and financing of the main workshop was pledged by USAID. During the preparation for the main workshop, the committee held regular progress updates via telephone every two weeks and face-to-face meetings each month. The coordination of fundraising with the Washington office of USAID was handled by the MoA and DLCO-EA, and identification of the main actors in the Ethiopian PDS was handled by the secretary. The main actors in the PDS identified in the process are listed in Table 7.

Table 7. List of actors in the Ethiopian Pesticide Delivery System

Government organizations	Intergovernmental organizations	Non-governmental organizations	Academia and Research	Private Sector
Ministry of Agriculture	Desert Locust Control Organization for Eastern Africa	Pesticide Action Nexus Association (PAN-Ethiopia)	Haromaya University	CropLife Ethiopia
Addis Ababa Urban Agriculture Bureau	Food and Agriculture Organization (FAO)	Institute for Sustainable Development (ISD)	Addis Ababa University	Adami Tulu Pesticide formulation company
Oromya Agriculture bureau			Hawassa University	Pesticide importers
Southern Nations Nationalities and Peoples Regional Agriculture Bureau			Ethiopian Institute for Agricultural Research	Horticulture development agency
Environmental Protection Authority				Ethiopian horticulture producers and exporters association

Government organizations	Intergovernmental organizations	Non-governmental organizations	Academia and Research	Private Sector
Ministry of Labor and Social Affairs				Oil seed producers and exporters
Horticulture development agency				
Ethiopian quality and standards authority				

During the preparatory discussions with the Washington office of USAID, the extent of pesticide problems in neighbouring counties and its trans-boundary nature were discussed. As complaints of illegal trading of pesticides with neighbouring countries were informally reported and this problem had also been the same in other countries, we came to an agreement to invite representatives of the Ministries of Agriculture of Djibouti and Sudan. The two ministries agreed to send representatives and a representative from the Washington office of USAID-Office for Disaster Assistance (OFDA) was also willing to attend the meeting and assist the process. The first workshop was, therefore, held from August 23-27, 2009 in Nazareth – a city 100 km East of Addis Ababa, the capital city of Ethiopia.

The workshop programme was set first to present the activities and challenges of each actor in the PDS and to indicate what contribution each actor institution would make to mitigate the pesticide problem. This initiative was appreciated by higher officials of the Ministry of Agriculture and DLCO-EA. The state minister of the Ministry of Agriculture and the director of DLCO-EA both attended the meeting and made speeches on the importance of a concerted effort to mitigate the environmental and human health impacts of pesticides in Ethiopia and the Horn of Africa region. The following section states the role of each actor institution as presented by the representative of the respective actors.

6.1.2 The role of the Ministry of Agriculture

The Ministry of Agriculture has been responsible for registration and control of the import of pesticides. Pesticide samples were randomly taken by research institutions and analysed to confirm whether the products met the required quality specifications. Through such a procedure, the import of unregistered pesticides, pesticides that did not comply with Ethiopian pesticide registration and control requirements and excessive import of registered pesticides were controlled. However, an interim procedure was also made for flower growers to import pesticides, including those that were unregistered.

The national distribution networks range from pesticide distributors and retailers to smallholder farmers. Most smallholder farmers receive advice on pesticide use from the dealers, even though traders rarely have appropriate training on use. Moreover, the traders mainly focus on promotion of pesticide trade and they have not been responsibly giving proper pesticide handling information. The extension agents at the grassroots level were also not well trained in how to convey pesticide risk related messages and the training curriculum was not developed taking this aspect into account.

It was also indicated that many pesticide users in the country lacked the resources, information and training to avoid risky practices. They said that poor practices resulted in spillages, over spraying and leaking. Pesticide poisoning to humans and damage to natural vegetation, natural enemies, beneficial insects (e.g. bees) and the environment occurred in different areas as a result of using a high amount of highly hazardous and broad-spectrum pesticides. Over-ordering/over-purchasing and oversupply had been common causes of accumulation of obsolete pesticides in Ethiopia. This had created a decades-long accumulation of obsolete pesticide stocks which have cost the country millions of dollars and years of effort. Needs assessment and proper planning was a mechanism the ministry was advising pesticide users to follow.

Considering the risk associated with pesticide use, Ethiopia has issued the Pesticide Registration and Control Special Decree No. 20/1990 to regulate the importation, sale and use of pesticides (FDRE, 1990). The responsibility of pesticide registration and control has been given to the Ministry of Agriculture. According to the Special Decree, pesticides were required to pass through a registration scheme before they were imported into the country. Subsequently, post-registration activities follow to promote effective use of pesticides in the country. Pesticide registration was granted on the basis of product effectiveness (at local level) and safety to humans, non-target organisms and the environment. In 2009, a total of 212 different types of pesticide were registered for use in agriculture and for the control of household pests.

According to the Special Decree No 20/1990 provided by the Council of Ministers to the Ministry of Agriculture, all pesticides should be registered prior to use within the country. No unregistered pesticide was allowed to enter the country. The Ministry of Agriculture was responsible for controlling the import of agricultural pesticides by issuing import permits provided that the application submitted by the importer contained the necessary data as prescribed by the Ministry. The data included: trade name, common name, percent of active ingredient and formulation, quantity, country of origin and purpose of import, port of entry, estimated date of shipment and estimated date of arrival. It was only after the Ministry had issued an import permit that the National Bank of Ethiopia would approve the necessary foreign currency for the import. The import permit was only valid for three months. Moreover, a pesticide may not be allowed to enter the country (i.e. not released by the Customs authority) unless it has been inspected by Ministry inspectors and packed and labeled as provided in the Special Decree, and unless the importer has produced written permission (i.e. an import certificate) from the Ministry. Occasionally, pesticide samples were also taken and analyzed to confirm that the products met the required quality specifications. Through such procedure, the import of unregistered pesticides, pesticides that do not comply with Ethiopian pesticide registration and control requirements and excess import of registered pesticides were controlled.

However, when the flower sector was considered as an important sector for the economy of Ethiopia, the Ministry realized that the types of pesticide registered did not satisfy the needs of the flower industry and there was an urgent call to update or upgrade the registration in order to respond to the growing demand. However, as the industry was growing steadily and the registration process required more time, an interim arrangement was made to allow only flower farms to import pesticides that were not registered within the country but registered in neighboring countries such as Kenya and Tanzania. These pesticides were to be evaluated based on the WHO hazard classification and pesticides listed under lists 1a and 1b were allowed in special cases. All the importation passed through the Ministry and a certificate of importation was given after inspection.

One of the problems in conducting proper registration was the low capacity of the research institutions to conduct efficacy trials on pesticides for flowers which was, and still is, one of the requirements for registration. Nevertheless, as capacity building to conduct trials on pesticide efficacy takes time, the Ministry developed a shortened registration procedure, referred to as the "transitional arrangement". The transitional arrangement was being carried out for pesticides that had been imported in to the country over the previous 2-3 years and which were being used by the flower farms. These pesticides were evaluated based on secondary data collected by members of the Pesticide Research Committee from the Ethiopian Institute for Agriculture Research (EIAR). The principle of this procedure was to replace the efficiency trial for the registration of these pesticides. Apart from this, the procedure was the same as the standard procedure for registration of pesticides and a complete dossier was required. According to this transitional arrangement, 168 pesticides had been listed and recommended. The applications submitted for registration in

2009 were for 80 products and were being evaluated based on their dossier and other requirements.

According to the pesticide Special Decree of 1990, the MoARD had (until 2009) the following duties:

a) Conduct pesticide registration based on the rules and regulations set by the office.
b) Prepare a list of registered pesticides and make this available to users.
c) Control the importation of pesticides that do not comply with the Special Decree by issuing a letter of import permit and issuing an import certificate.
d) Issuing a letter of competence assurance.
e) Control illegal pesticide trade in the country.
f) Prohibit the importation of highly hazardous, severely restricted or banned pesticides.

This decree also considered the international conventions that are agreed by the Ethiopian government. These are:

- The International Code of Conduct on the Distribution and Use of Pesticides,
- Basel Convention,
- Rotterdam Convention,
- Stockholm Convention,
- Codex alimentarius and the Codex Committee on Pesticides Residues

Even though the special decree was appreciated for the first application of a legal framework to manage pesticides, it had many gaps that the Ministry noted should be considered. The main gaps listed were:

- The role of Regional Agricultural offices was not covered
- The role of pesticide advisory body was not set
- Occupational safety was not given emphasis
- Offences and Penalties were not stated
- Detailed Power of inspectors was not indicated
- Provisions for Bio-pesticides were not given
- Definitions for some important words were not available (only a few words were defined)
- Disposal of pesticides was not covered
- Residue Analysis was not covered
- Appeals were not covered
- Storage was not covered

Moreover, overlapping of the mandate between the Ministry of Agriculture and the Ministry of Health was also a problem in the registration and control of pesticides because the definition of “drug” under Drug Administration and Control Proclamation No. 176/1999 included household pesticides and these household pesticides were managed by the Ministry of Health (FDRE, 1999). This required a higher level decision to bring the mandate of registration and control of pesticides to one organization. Considering the past experience and availability of personnel, the suggestion was to give the responsibility to the Ministry of Agriculture. Considering all these gaps, the Ministry of Agriculture prepared another proclamation which was deemed to fill the gaps and presented this to Parliament for ratification. The Ministry also invited interested actors to be part of the parliamentary hearing when the final discussion of the proclamation was open.

6.1.3 Reflection of Ministries of Agriculture of Sudan and Djibouti

The Ministry of Agriculture of Sudan, plant protection directorate is responsible for distributing pesticides to end users. Pesticides, however, are imported through importing agencies and delivered to the Ministry of Agriculture. A high number of different varieties of pesticides are applied to wider agriculture fields in Sudan, but the use of PPE is reported to be very low and misuse of pesticides was also reported. The lack of properly built pesticide stores was reported and pesticides were stored in open areas. The Ministry’s recommendations to solve the immediate problems of Sudan were provision of proper training, proper storage handling of pesticides and obsolete pesticide disposal arrangements.

The Ministry of Agriculture of Djibouti reported that the country did not have pesticide legislation. Pesticides had been used mainly for the control of mosquitoes and flies. The Ministry also reported that Djibouti is the country which all pesticide imports to Ethiopia had been passing through; and reported pesticide pollution at the store in the port where there had been a human poisoning incidence in 2002. The main problem of the country, according to the Ministry representative, was the lack of knowledge in pesticide management and the lack of a pesticide management and control policy framework.

6.1.4 The role of Crop Life-Ethiopia as a representative of the pesticide industry

Crop Life Ethiopia, the Ethiopian branch of Crop Life International (CLI), indicated that the main objective of the association is to assist its member companies in their endeavor to import and distribute safer and more effective crop protection products.

Crop-Life Ethiopia stated that it promotes and encourages the responsible and safe manufacture, packing, storage, transport, distribution and use of crop protection products in a manner that does not damage the environment. The representative also indicated that the association disseminated relevant information concerning crop protection products to the general public and created awareness, coordinated, expedited and assisted in safe and responsible handling and use. As part of Crop-Life International's Product Stewardship activity, Crop-Life Ethiopia had been facilitating the financial and technical support of CLI in the Africa Stockpiles Program (ASP), which was a multi-donor assistance project to dispose of 3,000 tons of obsolete pesticides from Ethiopia.

6.1.5 The role of the Desert Locust Control Organization for Eastern Africa (DLCO-EA)

The Desert Locust Control Organization for Eastern Africa (DLCO-EA) is a regional pest and vector management organization established by member countries in 1962. Initially, the organization was mandated to promote control operations and forecast techniques against upsurges and plagues of the desert locust, *Schistocerca gregaria*. Later, the mandate was extended to include better management of infestations of other migratory pests, such as the larvae of the African armyworm moth *Spodoptera exempta* the grain-eating red-billed quelea birds, *Quelea quelea* and the Tsetse flies that transmit the deadly human sleeping sickness, *Trypanosomiasis* or *Nagana* to livestock.

Major migratory pests, namely Desert Locusts (*Schistocerca gregaria*), African armyworm (*Spodoptera exempta*) and Grain-eating red-billed quelea birds (*Quelea quelea*) are the most destructive migratory pests in Eastern Africa. They can cause considerable damage to agricultural crops and pasture grasses and are a major threat to food security in the region, especially among smallholder farmers.

The desert locust is a very destructive migratory pest in Sudan, Eritrea, Ethiopia, Somalia and Djibouti. However, during upsurges or plagues other countries in the region can also be affected. For example, in 2007 desert locust swarms invaded northeastern Kenya, and southern and southwestern Ethiopia for the first time in 45 years. This was mainly due to the lack of skilled staff, on-time provision of pesticides, spraying equipment and safety devices in northern Somalia where it originated. Consequently, locusts that bred and developed in northern Somalia formed swarms and migrated to the neighboring countries of Ethiopia and Kenya. The Desert Locust Control Organization for Eastern Africa (DLCO-EA), in collaboration with the Plant Protection Departments (PPDs) of the affected countries, mounted extensive aerial control operations and prevented tremendous crop losses that would likely have been caused otherwise.

The African armyworm and quelea birds are major pests of cereal crops in Tanzania, Kenya and Ethiopia and to a certain extent in some other countries in eastern Africa. During outbreak years, larval densities of African armyworm exceeding 1,000 larvae per square meter were recorded by DLCO-EA in 1992. This clearly indicated the extent of damage that could be caused by larval densities of such a magnitude. Furthermore, vast areas are invaded by armyworm larvae during outbreak periods. For example, during the 2008 armyworm outbreak, some 900,000 ha of crop and pasture lands were invaded by armyworm larvae in Ethiopia. Similarly, in 2006, some 1.5 million ha of cereal crops and pasture grasses were invaded by armyworm larvae in Kenya.

Control Measures

The control of migratory pests is based on the use of synthetic pesticides in the Eastern Africa region. However, synthetic pesticides are inherently hazardous if not handled responsibly. They can cause serious damage to human health and the environment if the necessary safety measures are not taken.

The pesticides that are being used for the control of locusts and armyworm belong to the organophosphate, carbamate and pyrethroid groups. Fenthion and Cyanophos (cyanox) are the only two avicides available for the control of large colonies of quelea birds.

During armyworm outbreak periods, large quantities of pesticides have been used in the region. The 1993 armyworm outbreak was one of the worst in Ethiopia's recent history, and 339,972 liters of pesticides was used to control it.

Aerial control has been the only option available for the control of quelea birds in Eastern Africa. The quantities of pesticide used for control of these birds vary from one country to another, and large quantities of pesticide are used in Sudan for this purpose compared to other countries in the region.

Pesticides, spraying equipment and protective clothing have been largely provided free of charge by the national Plant Protection Departments (PPDs) for the control of migratory pests in the Eastern Africa region. The resources provided by the PPDs are often inadequate compared to the magnitude of the infestations. Consequently, the countries request external assistance whenever a migratory pest outbreak is heavy. FAO and other donor agencies step in and assist the countries in the provision of pesticides, spraying equipment and protective clothing and sometimes even cover part of the operational costs needed for migratory pest control operations.

Farmers participate in the control operations by undertaking manual spraying activities. DLCO-EA also assists its member countries by providing spray aircraft for aerial survey and control operations. The organization deploys its aircraft every year for quelea control operations in the member countries.

In its course of migratory pest control for more than 50 years, DLCO-EA indicated that the main challenges the organization faced have been:

- High probability of environmental contamination because of aerial application of wider areas during migratory pest occurrence pick seasons.
- High probability of obsolete pesticide accumulation because of guessed purchase prior to migratory pest occurrence; whereas migratory pests are not a problem every year.
- Lack of post-application monitoring of impacts on human health and the environment

6.1.6 The role of research institutions

The role of research institutions starts in identification of pest problems in potentially important commodities and design of appropriate management strategies that generally require development of effective and environmentally acceptable application of pesticides. These involve the identification of active ingredients, formulation to suit best distribution and application methods, generation of efficacy, toxicity and residue data, and registration of active ingredients that ultimately lead to mass production of different pesticides.

Research institutions have been involved in developing alternative pest management practices that utilize cultural methods, resistant varieties, biological agents, botanicals, chemicals and their combinations (as an integrated pest management option) aiming at reducing the impact of pests on the economy and environment, and at the same time minimizing pesticide hazards to health and the environment.

Research institutions have been involved in research activities related to establishing the importance of pest problems that include characterization of pest problems in the different ecological systems, identification of pests (mostly to species level and sometimes to sub-species, race and biotype levels), determination of the extent of damage and losses, characterization of the biology and analysis of pest occurrences, survival and dynamics in relation to cultural and environmental conditions.

Pest problems in a particular country depend on many factors of which agro-ecology, weather conditions, pest occurrence and cropping systems, among others, have a major influence. Hence, pest management becomes very subtle under such complex systems where appropriate and sound biological data are necessary to formulate sound management options. Research institutions, hence, play a major role in generating this important information and substantiate with sound practical and theoretical models. There have also been assessments on pest management options that include cultural methods, resistant variety trials, biological control and integrated management applications.

A scheme to test pesticides for their efficacy in major and potential areas was developed and endorsed by relevant stakeholders of the country where the Ministry of Agriculture has been the main responsible institution that regulates pesticide in the country. There are many documents available in the country that help to understand decision processes in pest management and regulating pesticide distribution in the country. The Plant Protection Society of Ethiopia (PPSE), Ethiopian Weed Science Society (EWSS) and other professional associations publish different articles directly or indirectly related to this subject. In general, these varieties of publication are fundamental sources of information on pest problems, their development and management options, and sources of recommended plant protection technologies useful to end users in the country.

Formal higher education at university level and training of thousands of development agents, subject matter specialists and farmers has been conducted. Regular training on practical applications and safe handling of pesticides have also been assisted by research, academia and the extension systems in the country. However, grassroots follow up of proper practical application was very limited. The design of appropriate methods of application, development of appropriate application equipment and design of suitable protective devices for the local weather conditions were very limited. Additionally, research institutions had limited involvement in interaction with the farming community on the use of pesticides and associated hazards, particularly discussing how pesticide hazards relate to work behaviors including cleaning, clothing, sanitation, handling of food and drink in working places and reading labels on containers by end users.

Acknowledging this gap, the research institution representatives identified the following problems:

- No sound and strong monitoring system that tracks pesticide impacts in the country.
- Insufficient laboratory capacity to conduct pesticide-related analyses.
- No or limited trained human resource in the areas of pesticide management.
- Proliferation of pesticide traders with low practical skills and technical capacity.
- Lack of strong enforcement and the existence of a porous boundary which allowed smuggling of unregistered and counterfeit pesticides into the country.

- Lack of data on national pesticide demand and supply and lack of networking for effective regulation of the PDS.
- Lack of good knowledge and skills in pesticide use and low level of awareness about pesticide hazard among the general public.

It was therefore recommended to:

- Develop capacity at national level on pesticide chemistry and biology to generate accurate and reliable efficacy, toxicity and residue data on candidate pesticides.
- Generate accurate and reliable data on population dynamics and epidemiology that helps develop prediction models for use as decision tools in pest management operations.
- Establish thresholds and develop spray schedules for important pests in different agro-ecologies of the country.
- Constantly develop alternative pest management systems and implement sound and sustainable IPM programs for important pests of the country to ensure responsible pesticide use.
- Develop pesticide regulatory procedures that work at district level – assessing pesticide storage, transportation conditions, market systems, quality at market level, and the qualifications, capability and skills of personnel dealing with pesticides. Monitor these and regulate their standards by enforcing the forthcoming pesticide proclamation.
- Provide training to create and increase awareness in society to play an active role in disposal of obsolete pesticides, containers and packages.
- Develop a sound national pesticide management program that collects and avails data on pesticides in the country.
- Create a national pesticide management network that facilitates information exchange and strengthens the national pesticide regulatory system.

6.1.7 The role of academia

Higher learning institutions are top of the ladder of education with the major mandate of exercising teaching-learning, undertaking research and also engaging in a wide array of community services. The role universities can play in the pesticide delivery system is substantial. There are opportunities to include it in some parts of the curricula in general, as well as in related disciplines in a more specific way, to educate students and concerned stakeholders on what pesticides are and the advantages and disadvantages of the use of pesticides to control plant pests and associated diseases. There is a need for a knowledge-based introduction of the whole aspect of pesticide uses, in this case, as the theme of the workshop puts it, the pesticide delivery system; starting from manufacturing/production, transport, delivery, storage and use by the end users.

The other major role of academia is research; that is setting different research agenda in relation to pesticide use and delivery issues. Such research objectives include general aspects of knowledge, attitude and practice of the use of pesticides, testing the quality and nature of pesticides, monitoring and checking the environment for contamination due to extensive and unwise use of pesticides.

Academia could be involved in outreach services to the community. They could raise awareness at rural and urban societal structures. The misconception of pesticides as the Amharic word *medhanit*, which means medicine, is widely held by many. This is just one example where much concerted effort by many stakeholders is required to clearly explain what pesticides are. Representatives of academia also presented the pesticide-related studies conducted in Ethiopia that are listed in Table 8.

Table 8. Highlight of conducted researches

Farm	Title	Main Result	Study Period	Published
Birr & Ayehu (West Gojjam)	Plasma Cholinesterase level	Cholinesterase level lower in sprayers	2005	(Mekonnen and Ejigu, 2005)
Birr & Ayehu (West Gojjam)	Pesticide use on agricultural fields & health problems	Chronic respiratory problems (cough, wheezing), ALP high in Birr	2004	(Ejigu and Mekonnen, 2004)
Upper Awash (Awara Melka, Nura Era, Tibila, Zewai)	Knowledge, Attitude and Practice of pesticide use	Careful work 93%, PPD 7%, Medical checkup 3%	1998-2000	(Mekonnen and Agonafir, 2002)
Northern Omo State Farm	Health Status of Northern Omo Farm workers exposed to Chlorpyrifos & Profenifos	Cholinesterase levels lower after pesticide spraying	1995	(Lakew and Mekonnen, 1998)

Importance of Sensitization and Awareness

The nature of the pesticide delivery system lies to a great extent in creating knowledge and awareness of the directly involved users, practitioners and by and large the whole community. The question is how can we achieve this seemingly easy but apparently very crucial issue? For instance, the participation of academia in professional societies is a good platform to organize different outreach programs to educate and also raise awareness of different stakeholders.

Difficulties encountered by academia

Dissemination of research results is usually limited to presentation in conferences and publications in scientific journals and in proceedings. Such methods of dissemination are also very important. Our experience shows that most of the time the research results do not reach all concerned parties. Thus the impact of our research output is very limited.

Resource is a crucial component of any research activity. Allocated research funds are inadequate and above all are not released on time; and the laborious procurement and purchase system in place is also a stumbling block to research undertakings in academic institutions.

Sustainability: lack of long term and sustained attention to a specific theme of research affects the research output. Based on experience, this is true for research in pesticide-related topics. The issue of sustainability is not necessarily short of funding but also suffers from a lack of motivation and a busy schedule with institutional assignments.

6.1.8 The role of Nongovernmental Organizations (NGOs)

Representatives of NGOs indicated that the economic benefits of pesticide use have been overestimated and the risks (health and environmental costs) of pesticides have been underestimated. Less emphasis had been given to balance the responsible utilization of pesticides for crop production and equally minimization of environmental and human health impacts. These led smallholder farmers to the consequences of improper utilization. Actors in the PDS and even sector government ministries did not possess integration at local levels in mitigating pesticide problems.

The main activities of NGOs had been in conducting smallholder-focused training on pesticide use and associated risks, dissemination of information on how to use pesticides responsibly and promotion of alternatives to synthetic pesticides. Training of farmers in IPM and ecological or organic farming techniques has also been mentioned as the main actions conducted by the NGOs. Since the NGOs were able to reach grassroots farmers easily, focused pesticide handling training and dissemination of research on local pesticide use were reported.

Of the research conducted and disseminated to the communities by NGOs, a section of the survey conducted by ISD in 2008 was presented in the workshop. In a study conducted in the Ethiopian Rift Valley with a total of 422 study participants, the result regarding use of protective equipment while farmers were spraying pesticides showed that 51.9% wore their normal clothes, 27.5% used cotton overalls, 8.1% used gloves, 8.5% used a hat, and 33.9% used boots. However, there were 14.0% who sprayed while their feet were bare. Only 5.5% who sprayed pesticides used eye glasses, while 3.8% used goggles for eye protection. As a protection against inhalation, 14.2% respondents tied a handkerchief over their mouth and only 1.7% used a mask.

Although there had been training opportunities regarding the use of pesticides, only 33.9% of the study participants indicated that they had been trained in pesticide issues. Of those trained, 26.3% indicated that they were trained on how to use pesticides, 12.1% were trained on health and safety issues, 7.1% were trained on IPM, 7.1% were trained on disposal, 12.3% were trained on application technology and 10.7% were trained on the environmental effects of pesticides.

Even though 44.5% of the respondents indicated that they could read labels on pesticide containers, only 29% could understand and follow instructions. Some 14.7% of them also indicated that they even bought pesticides without labels.

With regard to the health impacts of pesticides, 31% of the respondents indicated that they nearly always felt some discomfort and 9% indicated that they sometimes felt discomfort after pesticide application. Headaches were experienced by 25.8% of the farmers whereas 21.3% indicated a feeling of nausea, 19.9% indicated vomiting, 10.2% indicated skin irritation, 9.7% indicated eye irritation and 2.1% indicated other health problems after pesticide application. However, only 24.2% knew that there was a channel for reporting negative health impacts of pesticide use and 18.2% indicated that the channel of pesticide reporting was the local agriculture office.

Regarding obsolete (out-of-date) pesticides, 38.4% indicated that they continued using them, 24.4% indicated that they disposed of them in the soil and only 17.1% indicated that they sought advice from a development agent. Asked about the expiry date of pesticides that should be marked on the containers, only 24.9% looked for it on the original container.

Regarding empty pesticide containers, 49.3% indicated that they used these for water and/or food storage, 33.2% indicated that they buried them in the soil and 7.1% indicated that they sold them.

Regarding incidents of pesticide poisoning in the family, 14.2% of the families in the study indicated that it had occurred, of which 10.2% were poisoned and recovered, 2.6% had long term injuries and 1.4% had died because of the poisoning incidence.

The 14.2% of the households that had suffered poisoning incidents were asked when it had occurred: 5.5% said it had occurred during preparation for application, 5.0% during spraying, 1.9% as a result of poor storage, 0.9% during transportation, 0.5% during disposal and 0.5% as a result of an intentional suicide attempt.

As this problem cannot be left to be solved by one wing of the main actors, the NGOs highlighted the need of the concerted effort of all actors so as to mitigate pesticide problems in Ethiopian agriculture. The concerted effort, they indicated, could be a means to disclose existing pesticide impacts using research evidence, training, workshops and panel discussions. This would initiate a continuous dialogue forum at all levels to communicate the issues through radio and television programs, newsletters, leaflets, brochures, posters and scientific journals. This could be a bridge for all actors to look at their gaps in the PDS and to encourage them to fill the gaps in the confused pesticide use and handling situation.

Actors suggested to come together for a concerted effort were:

- Governmental organizations: The Ministries of Agriculture, Health, Industry, Labor and Social Affairs, Education, the Quality and Standard Authority, the Environmental Protection Authority and the Customs and Revenue Authority.
- Non-governmental organizations working on Environment and Development.
- Universities & research institutes for research-based support.
- Private sector: Pesticide companies, large-scale farms and environmentally-concerned citizens.
- Grassroots representatives: CBOs and Cooperatives of farmers.
- International organizations: Donors and development co-operations.

6.1.9 Pesticide Stewardship as per the experience from USAID

Pesticide stewardship has been an underused phrase in Ethiopia and the word 'stewardship' has also been new to the actors in the pesticide delivery system. The experience in the USA and the expertise from USAID was pulled in to act as an eye-opener to the actors in the Ethiopian PDS. This included approaching the case from problem identification to proposing a possible way of establishing a pesticide stewardship network within the national PDS and beyond. The following section is therefore the first insight about the issue and indicates how pesticide stewardship can be designed within actors that have already committed themselves.

Reason for establishing pesticide stewardship network

Pesticides play a crucial role in agriculture, public health, industry, livestock, environmental protection and so on. Most of the high-volume pesticides are manufactured in developed countries, mainly in North America, Europe and the Far East, including Japan. The use of these products is also enormous in these countries, where over 75% of use takes place compared to the less than 25% of the global consumption taking place in developing countries. Highly toxic and banned pesticides have easy access to the Developing Countries (DCs) markets and old and leftover stocks are enormous in these countries (Belayneh and Vorgetts, 2000, FAO, 2003, Vijgen and Egenhofer, 2009). Such products obviously pose very significant human health risks and environmental threats. Increased knowledge and skills help reduce pesticide problems and creating an alliance between and among the public sector and private sector can contribute to the national pesticide delivery system (PDS). The result of these multiple processes will then lead to and can enable the transfer of knowledge adaptable to the existing PDS and ultimately help protect human health and environmental safety. Important lessons learned from local and external sources need to be encouraged in an attempt to make the creation of a continent-wide pesticide stewardship network a reality.

Proposed Objectives

The primary objectives of pesticide stewardship programs have been to:

- Optimize responsible pesticide use;
- Reduce environmental and human health risks;
- Improve quality of life and
- Save lives and resources.

Stewardship – Definition

The definition of stewardship given by a representative of USAID was "*the responsibility to take care of something that one does not own"*. Extended stewardship or responsibility is a process where stakeholders share responsibilities to reduce human health risks, ensure environmental safety and maximize resource utilization through planning, designing, regulating and implementing responsible and effective marketing, transporting, use, handling, recycling and disposal of pesticides. A broader stewardship networking can assist the development and implementation of effective and sustainable PDSs in all countries in the Horn of Africa.

Key elements of Pesticide Stewardship

A pesticide stewardship program is based on a number of elements that are important to the successful improvement of a PDS. The most salient of these elements are as follows:

- Developing partnerships among various sectors;
- Promoting and assisting regulatory instruments;
- Encouraging participation and engagements in crucial PDS elements;

- Recognizing the importance of a PDS to sustainable agricultural development programs that will contribute to food security and the national economy and
- Entrusting the raising of awareness in human safety and environmental protection with factual, field-tested and useful information.

The Beginning and Ending of Pesticide Stewardship

Pesticide stewardship begins the moment a researcher or investigator conceives of an idea to develop a product or products that will help tackle the problems and challenges that humans face trying to protect their health and valuable assets against externalities such as pests and diseases. Though the process starts at the researcher's drawing board, it will continue until the final product is achieved, i.e., appropriately used for the intended purpose with unusable and aging leftovers being safely destroyed or disposed. In other words, the process involves an array of actions taken at the stages of researching, manufacturing, formulating, transporting, trading, vending, distributing, applying, storing, regulating, recycling and disposing. It can thus be rephrased as *from cradle to grave* in terms of a product's life cycle.

The cradle-to-grave conceptual process involves a number of accepted practices such as good laboratory practices, good agricultural practices as well as extended product stewardship and high quality customer services (FAO, 2003). These processes include, but are not limited to:

- Ensuring appropriate procedures and practices in production, formulation, importation, exportation, use, storage as well as management of pesticides;
- Encouraging distribution or sale of the right quantities of pesticides for the right target;
- Allowing market access only to registered products and denying access to unregistered, banned or discontinued products that often constitute counterfeit materials;
- Encouraging and ensuring spray operations are carried out only by skilled and certified applicators;
- Promoting, encouraging, and enforcing the use of appropriate PPEs at all times and
- Establishing standards for capacity building/strengthening through knowledge sharing and information dissemination.

Importance and implementation of Stewardship

Pesticide stewardship is implemented through a network of stakeholders that have a stake in the pesticide sector, agriculture and agro-industry, public health sphere, regulatory processes, information sharing and dissemination, awareness raising, environmental protection and many more (VirginiaTech., 2002). The process can be launched through various means and venues, including:

- Meetings and think-tanks
- Training and workshops
- Electronic communications
- Demonstration trials, actual operations
- Bulletins, fliers, posters
- Awareness raising at vendor, end-user, regulator and inspector levels
- Engaging local and external advisory groups.

Activities that can be carried out thought the above-listed venues may involve a variety of issues. Issues of critical relevance to strengthening a PDS will include promoting and ensuring appropriate and adequate packaging, ensuring appropriateness of product labeling and a material safety data sheet in consumers' languages, encouraging end users to purchase and vendors to sell *only* appropriate types and quantities of products, promoting collection and safe disposal/recycling of leftover stocks, and creating an association of national pesticide stewardship networks to help facilitate and strengthen the national PDS.

A well-designed stewardship approach improves the knowledge and skills of the end users. It promotes and ensures the judicious use, handling and management of pesticides. The informed end-user, vendor, regulator and inspector can avoid counterfeit products that are often associated with health risks and environmental threats. Such practices ensure equitable access and distribution of products, help avoid overstocking and wastage, eliminate disposal problems, optimize resource utilization and ultimately contribute to human safety, protect the environment, enhance food security, and contribute to the national economy.

Strategy and Mode of Operations of Stewardship

Pesticide stewardship strategies are launched and operationalized through various venues. The primary strategy of the stewardship process is to strengthen the existing delivery system in close collaboration with and by enhancing and using the existing technical and material resources. Among the first line of defense are the local agricultural experts and other sectors relevant to the PDS. The process will strengthen the existing PDS structure by enhancing the existing capacity and filling the gaps wherever possible. The process would involve multi-tasking and would require multiple years of effort for the creation of a fully-fledged and self-operating system (VirginiaTech., 2002).

The stewardship process has wide-ranging beneficiaries and contributors. While most of the beneficiaries can form a clientele basis for the stewardship process, some can also contribute to the process that is the cornerstone of the national PDS, and among these are:

- Large and small vendors;
- Large and small-volume consumers;
- Government entities, including Ministries of Agriculture, Health, Trade and Industries, Transport, Environment, and so on. that regulate, inspect and/or provide products;
- Researchers, educators as well as civil society organizations.

Principal Goal of Stewardship

The primary goal of stewardship is to strengthen the national PDS through a network of partners. This will be done to ultimately improve the safety of farms, increase quantity and quality of food, protect the environment, promote IPM for greater economic efficiency and maximize resources (VirginiaTech., 2002).

Broader Activities of Pesticide Stewardship

Pesticide stewardship activities can be broad and include various aspects of the pesticide management and application processes. The stewardship process begins at a well-researched production level where safety and handling aspects of the products are carefully investigated before rolling them out. As soon as the product is off the production line, the marketing component kicks in with force and at times far more aggressively than one would expect. Monitoring and regulatory processes are much needed from this point on, although they are visible throughout the process. It is critical for the regulatory bodies to fully deploy and engage at the marketing level as much as in other areas, as the market is key to unfolding many of the existing problems such as the stage where counterfeits and dangerous and illegal products first present themselves to the uninformed buyer.

Decision-making processes and policy dialogue are as important as many other aspects and at times even more so than most basic activities. These processes are key to the development and survival of sustainable stewardship programs that would require both enabling policy tools and the building of a strong coalition among core groups, i.e., the national plant protection units, the health and environment experts, food safety entities, industry as well as the advocacy groups, including civil society organizations.

6.1.10 Consensus of the actors

While efforts made through various venues can contribute to the betterment of a national pesticide delivery system, the critical role that pesticide stewardship can play in improving and strengthening the system was agreed on by all actors. It was also highlighted that a national PDS can benefit from enhanced proactive awareness raising and increased training programmes as well as improved self-compliance and behavioural change among stakeholders. A transformed PDS can then reap the benefits of proper enforcement of legislation and regulatory procedures. It can yield empowered communities with the capacity to monitor pesticide health impacts and develop and use safer and more affordable alternative techniques and products. It will also hold a cherished position as the focal point for dialogue and routine engagements among all actors in the PDS that transcend political boundaries and transform the current state of pesticide problems to a state where it is envisaged.

All actors agreed on the existence of pesticide problems in Ethiopia and everyone agreed on the establishment of a multi-actor based system-wide pesticide stewardship network. The notion of pesticide stewardship is believed to link every actor in a shared sense of responsibility at all levels of the PDS to bring about an ethic of reduced and responsible use of pesticides to minimise the impact on human and environmental health. The network was viewed as a platform for collaborative learning and collective action driving institutional change at many levels. National, regional and local level engagement of the actors in the PDS was envisaged to follow in the next steps so as to facilitate policy dialogue workshops, pesticide risk communication and risk reduction dialogues; and to promote action-oriented training workshops and Farmer Field School (FFS) approaches.

Following a detailed discussion, a nucleus of the national pesticide stewardship network was created with a unanimous agreement by the participants. It was also agreed that the network would be run by a seven-member provisional executive committee. The committee was composed of a chairperson, two vice chairs, a secretary, an alternate secretary and two additional executive committee members. Nominations were carried out by the participants and members were selected and approved. Accordingly, representatives of the following institutions were elected to assume corresponding responsibilities:

- Ministry of Agriculture Chairperson
- DLCO-EA Vice Chair I
- Addis Ababa University Vice Chair II
- PAN-Ethiopia Secretary I*
- Crop-Life Ethiopia Secretary II
- EIAR Executive Member
- Private sector Executive Member.

The executive committee was mandated with the naming of the network, gaining legal recognition for the network/association by registering it with the appropriate authority. The executive committee was also mandated to encourage members and seek assistance required for the formalities to be followed in the registration process, which included providing development of a bylaw to be submitted to the government agency that provides legal registration. (**I was assigned as the first secretary of the provisional executive committee which also gave me a chance to follow the process on a daily basis*).

Follow-on steps of the network

As the secretary of the network, I started acting as a broker in the process and coordinating the executive committee and members so as to develop the bylaws of the envisaged network and a project proposal to be submitted to donors and the Ethiopian registration agency.

The first step of the dialogue with the executive committee and members of the network was discussing how "stewardship" should be defined and approached from the Ethiopian context. Considering the human health and environmental impacts that pesticides pose in Ethiopian agriculture, the agreed text was "System-wide Pesticide user's stewardship", which was defined as: *the building of a shared sense of responsibility at all levels of the pesticide delivery system to bring about an ethic of responsible use of pesticides to minimise the impact on human and environmental health*. The network was viewed as a platform for collaborative learning and collective action driving institutional change at many levels. Following this, national, regional and local level engagement of the actors in the PDS has been attempted. The policy dialogue workshops at the federal level led by the executive committee developed a proposal that engaged all actors to intervene in pesticide risk communication and risk reduction dialogues at regional level and to support action-oriented training workshops and Farmer Field Schools (FFS) among vegetable and cotton growers at grassroots level. Prior to the development of the proposal, consultation with representatives of agriculture experts from all regions in Ethiopia was suggested by the Ministry of Agriculture. The Ministry of Agriculture, therefore, brought 28 regional agriculture bureau experts and 22 district extension agents at two different times. The experts and extension agents presented the pesticide situation in their respective regions and they were set for a focus group discussion to clarify the situation.

6.2 Focus group discussion

Focus group discussion questions were prepared to obtain an insight into the essence of the relevant systems of the pesticide delivery system in Ethiopia, to identify the weak link in the pesticide delivery system, and to assess the challenges of the extension system in mitigating the problem. Checkland's Soft Systems Methodology was used as a tool to frame the group discussion (Checkland and Haynes, 1994). The focus group discussion points focused on identifying the system's beneficiaries (Customers), the actors who are deemed relevant in transforming the current situation to where it ought to be (Actors), the process which leads to the desired situation (Transformation), the relevant world views in the system (Weltanschauung), those who have power to influence the transformation (Owners) and the environmental constraints that need to be considered in the transformation process (Environmental constraints) – adopted together as the CATWOE checklist used by Checkland.

The agriculture experts and extension agents from different parts of Ethiopia were asked to present the problematic situations in their respective areas. The reaction from all regional representatives was similar. They indicated that farmers use cheaper pesticides and they mix insecticides with herbicides with the intention of creating a synergistic effect for pest control. They reported that pesticides without labels had been bought by farmers and they noted that farmers usually use obsolete pesticides.

They rated farmers' risk perception as low because they saw farmers mixing pesticides at home near children; and in the field near sources of water, applying pesticides without appropriate personal protective equipment, storing pesticides anywhere in the house and using pesticide containers to store and transport food and drinks. They affirmed that improper methods of pesticide application, which were acquired from families, friends and neighbors, outweighed the information they received from agriculture extension agents.

The socio-cultural reasoning they indicated as a cause was that in the national language and in almost all local languages, the corresponding term for pesticide was "medicine", acknowledging these chemicals as friendly and useful products rather than conveying the idea that they are actually poisons. This understanding coupled with the level of illiteracy was indicated as one of the reasons for the worst situations of using pesticides to treat human and animal ecto-parasites and also to treat human and animal ailments.

The economic reason the discussants gave for the situation was that the farmers selected cheaper pesticides and even pesticides without labels and they hardly bought any personal protective equipment to be used during preparation and application.

The national agriculture extension system had mainly been engaged in increasing crop production and expansion of the distribution of agricultural inputs to farmers. Pesticide risk communication is not listed under the curriculum of the training being given to farmers at the grassroots level. The discussants, therefore, suggested the importance of the concerted effort of all actors in the pesticide delivery system rather than leaving the responsibility to only the government, whose effort has not succeeded in bringing responsible pesticide management practices for the last forty years. It was highlighted that the situation required the attention of the government as a policy maker to take the lead to mitigate pesticide poisoning incidents by developing a risk communication strategy to be used by all actors in the pesticide delivery system, pesticide industries, importers and distributors, and for them to work together with other actors to mitigate the unintended impacts of pesticides; non-governmental organizations to make pesticide risk communication part of their curriculum during their outreach to the grassroots farming community; and academic and research institutions to give a wake-up call with evidence-based risk alarms and provide guidance on how different actors in the pesticide delivery system could come together and conduct an action-oriented risk communication program.

The discussants argued that the current situation should be transformed to a better understanding of what pesticides are, what they should be used for, and their negative and positive implications for the 85% of the population which depended on agriculture. This being the desirable transformation, the discussants indicated that its feasibility could be challenged by the different interests of actors in the pesticide delivery system which would widen the gap from making policy to regulate the registration and control at the top, ethical production of chemicals and profit making by the industry, importers and distributors in the middle; to getting the best use out of them to result in increased crop production by the end user farmers.

In addition to the abovementioned challenges, poverty and illiteracy were also indicated as the main obstacles which may hinder ignition of the process of engagement of all actors so as to make participatory action in mitigating pesticide hazards a regular task of concerned citizens, not only of the government and/or NGOs.

6.3 Legal registration and higher level discussion

Considering concerns of the PDS at different levels, the executive committee developed a project proposal entitled “System-wide pesticide stewardship towards prevention of the public health and environmental impacts of pesticides in Ethiopia”. A bylaw supporting the proposal was also developed with the objective of enhancing and promoting a safe and sustainable environment protected from harm posed by pesticides by promoting the close collaboration of all actors in the pesticide delivery system. This was accepted by the Ethiopian Charities and Societies Agency (a government body providing legal registration) and we were advised to establish the initiative as an association (not as a network). In 2011 the initiative was legally registered as the “Pesticide Stewardship Association” (PSA). A series of workshops under the auspices of the newly-formed PSA were then conducted in the next phase of the research project at the three levels of intervention.

6.3.1 First level workshop

The first level workshop was conducted from July 25-26, 2011 involving all actors in the PDS of Ethiopia and the representative of the Washington office of USAID as well as two professors from the Swedish University of Agricultural Sciences (SLU) because of the link created with the PhD study. The discussion this time started by appreciating the pesticide problem in Ethiopia and the consensus of all actors to act towards transforming the existing situation.

The pesticide problems presented in the previous workshop and focus group discussions were mapped and presented to the actors so as to devise an agreed plan for its transformation. The problem analysis came out as an immediate effect, with details of what brought about the effect and the underlying cause:

A. Immediate effects: the immediate effects of pesticide use reported by researchers and experts were:
    - Pollution of water, aquatic biodiversity, livestock, crops, export commodities
    - Pesticide dependency because of effects on non-target organisms, pest resistance and results of reduced productivity
    - Human poisoning which results in acute effects including death; and long-term effects such as carcinogenicity, mutagenicity and bio-accumulation, which will ultimately lead to death

B. Immediate causes which resulted in immediate effects:
    - Low level of knowledge, incorrect perception, improper handling, misuse, mixing near water bodies, not giving safety period before reentry into sprayed fields, mixing unmixable pesticides, improper dose, misuse of pesticide containers, using obsolete pesticides, blanket application and not using protective equipment

C. The underlying cause of the current pesticide problems were:
    - No properly crafted curriculum for training on responsible use, less enforced pesticide registration and control decree, policy that supports only high input agriculture, no national IPM policy, no provision for alternative pest management, less involvement of research and academia in problem solving, less involvement of the private sector, less involvement of media, illegal trading, no resource center for locally-related issues, less research and learning in the field (problems mainly expressed based on anecdotal stories), no poison center in health facilities, health professionals not being trained on how to handle poisoning cases and no chain of incident reporting.

As this is the situation that involves all levels of society, it was discussed that it should be approached as a system-wide issue requiring learning as a network which is mainly related to the high level PDS at the PSA level; learning in a team, which mainly requires linking the initiative with an already-organized team or organizing a new team that can share the PSA's vision; and finally learning in communities which requires getting a community ready to be part of the learning and knowledge production process. The higher level PSA was, therefore, ready to take this initiative with the approach of learning in a network so as to contribute to initiatives that lead towards the common goal of pesticide users' stewardship. For the approach of learning in a team, the Ministry of Agriculture recommended approaching district agriculture offices in the Central Ethiopian Rift Valley area where pesticides have been used extensively for horticultural pest control. The district agriculture office agreed with the initiative, which led PSA to strategize approaches in relation to pesticide risk communication in this area. The third level of learning in communities was agreed to strengthen the already started (but interrupted) cotton-IPM practising smallholder farmers in the Southern Ethiopian Rift Valley, Arba Minch area. These cotton farmers received a one season IPM-FFS training by the Ministry of Agriculture and FAO in 2006 as part of the prevention component of the Africa Stockpiles Program, but it was stopped after the project was phased out. Having set these approaches up, the PSA actors conducted group discussions and came up with the strategy of transforming the current status of pesticide use and practice to the situation where they envisaged it should be. The groups followed the problematic situation and envisaged system-wide pesticide stewardship as follows:

A. Envisaged immediate effects from responsible use of pesticides through a system-wide pesticide users' stewardship:
    - Farmers understand responsible pesticide use and act accordingly, which results in less/no pollution , no effect on the economy, less risk of pest resistance and less dependency
    - Less/no poisoning, which results in fewer health effects and sustainable agriculture
B. Immediate responsible actions that contribute to the transformation:
    - Establishing learning platforms and facilitating an involve-all knowledge production at all levels of the PDS, conducting research to fill existing gaps, promoting alternatives to pesticides, involving media for communication
C. Underlying actions that guide an evident transformation through the PSA:
    - Participatory learning spaces as part of the extension system, developing a communication strategy, establishing a chain of poisoning reporting system, establishing a poison center and training health professionals on how to handle poisoning cases, conducting action-oriented and problem-solving research, strengthening transdisciplinary collaboration, system-wide monitoring and evaluation on the issue, developing national IPM policy frameworks and enforcing pesticide registration and control proclamation.

6.3.2 Second level workshop-learning in teams

The second level regional workshop was conducted in the city of Ziway, 160 km south of Addis Ababa, with a focus on pesticide risk communication issues. The district agriculture office invited representatives from local government, the health office, education office, plant health clinic and from flower farms. The district representatives presented their pesticide poisoning cases and it was similar to what was presented at the PSA workshops. A detailed survey-based study of the Ethiopian Rift Valley area was conducted from 2008-2011, which collected field-based data including situations such as Figure 3 and was presented to the workshop, which was agreed that the results showed the reality of the area.

Figure 3. Smallholder farmers mixing pesticides and pouring into a knapsack sprayer from a mixing barrel without protective clothing during pesticide application, Ziway (Central Rift Valley of Ethiopia) (Photo: Tadesse Amera).

The way pesticides were mixed and applied as seen in Figure 3 and the conversation we had with the local actors revealed the level of pesticide-related risk in the area. Moreover, it was also mentioned that pesticide contact time after application was not respected and people were seen harvesting and consuming products while pesticides were applied in the field.

The report from the flower farm plant protection experts and district agriculture extension agents about how pesticides were used within flower farm greenhouses was also similar. It was reported that flower farms used more dangerous pesticides and applicators did not use proper personal protective equipment. Moreover, most flower farms were adjacent to Lake Ziway, which meant that the lake was vulnerable to contamination from highly hazardous pesticide formulations. When the PSA team had a discussion with the management of the flower farm in their compound, however, they claimed that they provided personal protective equipment to their workers and they made sure that the equipment was used.

Looking at the level of pesticide risk in the area, the PSA team took an assignment to follow the situation in this area so that pesticide risk communication could be handled properly and a mechanism of an agro-ecological approach through a collaborative learning space could be introduced in the area. Following this process, the Ministry of Agriculture together with the FAO and Wageningen University developed a Pesticide Risk Reduction Program (PRRP), which focused on research and development as well as policy support and promotion of alternatives to synthetic pesticides with a particular focus on the introduction of biopesticides. The Ministry involved all the PDS actors in the process and this was appreciated as a good practice to be adopted by others in the Eastern Africa region. The Ministry of Agriculture progressed in ratifying the pesticide registration and control proclamation in

2010 and with the help of PRRP it managed to consult all actors in the PDS to develop a draft regulation which aimed to help the enforcement of the proclamation at different levels throughout the country.

Moreover, Addis Ababa University, PAN-Ethiopia (NGO), ISD (NGO), Ethiopian Wild Life and Natural History Society-EWNHS (NGO) and the Ethiopian Institute of Biodiversity Conservation (Government institution), in collaboration with partners from the UK, secured funding from Defra of UK in April 2013 and implemented a project on "*Mitigating pesticide impacts on biodiversity through agro-ecological solutions*" which also conveyed the principle and notion of pesticide users' stewardship in a wider perspective. This involved local and national actors as learning teams to come together and look into the ecosystem approach of agriculture production and assisted agriculture extension workers, school environmental protection clubs, farmers and government officials to conduct ecosystem walks, record the ecosystem benefits, watch birds as indicators of environmental health and discuss the applicability of agro-ecological approaches which could minimize pesticide burden on the human body and the environment.

6.3.3 Third level workshop-learning in communities

The third level workshop was conducted in the Southern Ethiopia Rift Valley area, Arba Minch area, which is 500 km from Addis Ababa. This area was chosen because cotton is grown here by smallholder and commercial farms and pesticide use for cotton production is high. As mentioned above, IPM-FFS was also tested and it was shown that it could work in the area. The reason the PSA team came here was to look at the possibility of taking the previously IPM-FFS engaged farmers as learning communities and to implement more robust IPM-FFS in the area as an agro-ecological action research that could mitigate pesticide problems in the area. During the workshop, the farmers indicated that the previous FAO & Ministry of Agriculture initiated cotton IPM-FFS was a life changing process, but they complained that the project was phased out before they became strong enough to continue by themselves. PSA took note of the farmers' motivation of continuing the cotton IPM-FFS work and encouraged the members to look for funding so as to link this initiative with the general shared notion of pesticide users' stewardship.

Following this process, PAN-Ethiopia, ISD and the Ministry of Agriculture continued technical support just after the PSA workshop in Arba Minch in 2011. The three organizations, in collaboration with PAN-UK, developed a project proposal on wider expansion of IPM-FFS in Gamo Gofa Zone and secured three years of funding from Textile Recycling Aid for international Development (TRAID), a UK-based organization, which was implemented from January 2013. The first round of IPM-FFS practical training and field application of a locally-made pest management system indicated the possibility of reducing the use of pesticides. Comparison of conventional and IPM-based cotton gave a wider variation of 1.5 tons and 2.3 tons per hectare respectively in the first year. A total of 2,086 farmers within the three areaswere engaged in cotton IPM and this process has been demonstrating participatory action research which involved actors in the PDS in Ethiopia. Lead farmers who had taken IPM-FFS training since 2013 served as facilitators in their respective areas and were also taken to interested new areas to provide training. On the other hand, selected lead farmers from each village were taken to the Central Ethiopian Rift valley (Ziway area) to show the feasibility of agro-ecological approaches in the farming system. The project started in three villages in 2013 but it had reached 9 villages by the end of 2015. Moreover, smallholder cotton farmers organized themselves into a cooperative and have been developing their internal control systems as a precondition to secure an international organic certification in order to access the international market. Women in the first three villages have also organized themselves into traditional a cotton spinning association so as to empower themselves in diversifying their income and add value to the locally-produced traditional cloth. The details of the FFS process and the pest management techniques used are indicated in detail in section 6.5.

6.3.4 Barriers faced by PSA

The four years of activity within PSA (since 2011) was aimed at laying a foundation for the network for PSA to become an action-oriented and policy-directed initiative leading to the creation and support of a platform for institutional innovation in the PDS. In line with this, a three-year project proposal was developed and shared with members to seek funding. However, none of the attempts was successful in soliciting funding for PSA (as an independent organization). The directives of the Ethiopian Charities and Societies Agency (CSA), on the other hand, obliged PSA to solicit funds and deliver an annual financial and activity report. Since PSA itself (as an independent organization) was not able to secure funds but all the activities were being conducted by the member organizations, it could not deliver an activity report to the agency which would have aligned with the financial expense of its account. During a follow-on third round of workshops conducted in 2013 in all the three levels, the members of PSA agreed to maintain PSA as an informal network which could support the pesticide risk communication work in the Central Ethiopian Rift Valley area and the cotton

IPM-FFS work in the Southern Ethiopian Rift Valley area. Moreover, it committed itself to facilitate the learning and policy dialogue at higher levels and bridge gaps between policy and practice at regional and local levels.

6.4 Pesticide Risk perception survey in the Ethiopian Rift Valley

This section of the thesis is based on the questionnaire-based survey in the Ethiopian Rift Valley from 2008-2011 triangulated with field observation, qualitative data from farmers' focus group discussion with experts and further validation of a field assessment in 2015.

The whole process revealed that farmers use pesticides because they wish to manage/control pest problems that attack their crops in an easily accessible way. This "easily accessible" option for them is the use of synthetic pesticides. However, unfortunately the chemical-based option of pest management was not able to deliver only the positively intended purpose of managing/controlling pests. Rather, it created problems that can easily be identified (such as acute poisoning cases) or more complicated problems (such as chronic health conditions) which are still under investigation in order to obtain scientific evidence after decades of use.

6.4.1 Survey results

During the survey which was conducted from 2008-2011, 50% of the study participant smallholder farmers indicated that they did not think that pesticides constituted any harm to human health. It was also found that they were not using Personal Protective Equipment (PPE), they were using empty pesticide containers for food and drink storage and most stored pesticides anywhere in the house, including in kitchens and bedrooms. Table 9 shows major pests of farmers in the Ethiopian Rift Valley.

Table 9.Common pests in the Ethiopian Rift Valley.

Insects and other Arthropods	Onion Thrips (Onion), Aphids (Cabbage, Pulses), Bollworm (Pulses, Onion) Diamond Back moth (Cabbage), Fruit fly (Tomato), Fruit worm (Tomato), Stalk borer (Maize), Cut worm (Nursery vegetables, Maize seedlings), Termites (Grass, Teff) , Army worm (Cereals), Grasshopper (Cereals), Leaf Minor (Tomato), Tuber moth (Potato, Tomato), Spider mites (Tomato), Plusia worm (Maize, Haricot bean, Onion, Cabbage), Bean stem maggot (Pulses).
Plant Diseases	Late blight (Tomato, Potato); Early blight (Tomato, Potato); Purple blotch (Onion); Leaf spot (Tomato); Basal rot (Onion); Antracnose (Haricot bean, Mango); Gray leaf spot (Maize); Leaf blight (Maize); Leaf rust (Maize); Yellow rust, Stem rust (Wheat, Barley); Fusarium wilt (Pepper, Tomato); Bacterial canker (Tomato); Rot diseases (Onion, Cabbage, Garlic); Damping off (On seedlings of vegetables and others); Nematodes (Pepper, Tomato, Haricot bean, Wheat)
Weeds	Noxious Invasive Alien Species. *Parthenium hysterophorus L.*; *Eichhornia Crassipes*; *Lantana camara*; Annual Broad-leaved weeds; Annual and perennial grasses Parasitic weeds : *Orobanche Minor* (Tomato) and *Orobanche ramose* (Tomato)
Vertebrate pests	Field and storage rodents. Grain-eating birds: - Local birds - Migratory birds (Quelea Quelea)
Storage pests	Common weevil species Common beetles Grain moth

Source: Ziway plant health clinic, 2011

Chemical pest control was the method of choice for most farmers in the study areas except those producing coffee. Farmers in coffee-producing areas as well as their district agriculture offices indicated that they did not use pesticides and artificial fertilisers for coffee. Among other intended uses, all the farmers in the study areas indicated that they mainly used insecticides as a proven solution for most of their pest problems. During data collection in 2008, 29% of vegetable producing farmers in the Ethiopian Rift Valley area were found to be using Dichloro-Diphenyl-Trichloroethane (DDT) for vegetable and khat pest control. Moreover, farmers used DDT for maize storage pest control. It was also mentioned that DDT made khat leaves shiny and more attractive to buyers and hence fetched a higher price per kg.[4] Farmers claimed that they bought DDT from public health employees (authorized to use DDT only for indoor spraying for malaria control). Further investigation also revealed illegal sale of DDT in open markets of different villages in different parts of the Ethiopian Rift Valley area. The use of DDT for malaria control was however stopped in Ethiopia after 2011.

[4] Khat (*Catha edulis*) is the source of a mild stimulant; people chew the raw leaf as sold in the market without washing it. It can be dried but it is never cooked.

6.4.2 Pesticide risk perception-taking DDT use as a case

The reason farmers gave as to why they were using DDT was that they knew from their past experience that DDT was an effective insecticide and they were not able to find another chemical to replace it. They also mentioned that they did not know about the Stockholm Convention and any environmental and human health consequences that DDT may bring. As a result, there were findings that some farmers mixed DDT powder with water and used it for cattle de-worming; and it was reported that elderly people in remote areas of Southern Ethiopia drink small coffee cups of DDT for malaria prevention. They also reflected that they did not see any acute poisoning effects after using DDT and they believed that DDT was harmless to human health.

Taking this into account just after the 2008 survey, Amera and Abate (2008) together with researchers from the NR-group in the UK compiled a human health and environmental rapid risk assessment for DDT. With regard to the effect of DDT on human health and given the poor level of understanding of pesticides and poor pesticide management uncovered by the survey, it was clear that there had been a significant risk to those who used and applied DDT. DDT use and application result in relatively low acute toxicity (nausea, diarrhoea, increased liver enzyme activity, irritation of the eyes, nose or throat, disturbed gait, malaise and excitability) to people who use and apply it. The key risks of contamination are to children from accidental ingestion of DDT stored within the house; to families through drinking DDT contaminated water, although it is insoluble so they need to drink water containing particulate matter or sediment to ingest it, and to families through eating contaminated fish or other freshwater animals caught locally. DDT does not generally contaminate groundwater and there is a very low risk of this happening in the Rift Valley. Women exposed to DDT can accumulate residues in breast milk, thus leading to exposure of suckling infants. DDT is mutagenic/genotoxic, causing chromosome aberration or damage, and it may also be teratogenic, causing impaired learning and/or impaired physiological development. There is also disputed evidence over its carcinogenicity. DDT is suspected of having caused increased tumours in lungs and liver in mice. Prolonged exposure is suspected of inducing leukaemia in mice. There is also disputed evidence linking DDT exposure with breast cancer in women. The potential for prolonged exposure to DDT does exist within the Rift Valley and there is the risk that amongst the population there, there may be people who suffer from the above hazards.

The availability of DDT in the agriculture sector was further verified by human breast milk analysis in 2012. As part of the global monitoring program of the Stockholm Convention; the Ethiopian Environmental Protection

Authority in collaboration with the local NGO PAN-Ethiopia (where I have been based) collected 50 pooled samples of human breast milk from different parts of Ethiopia, including the study area where this section of the thesis was based. The result of the pooled samples analyzed by the WHO/UNEP reference laboratory which was presented at the sixth conference of the parties for the Stockholm Convention (COP6) revealed that the levels of DDT from Ethiopian samples were by far the highest in all countries from which samples were received and analyzed in the year. The level of (un-metabolized) p,p'-DDT was 10,734 ng/g lipid weight and that of p,p'-DDE as a usual metabolite of DDT was 10,518 ng/g lipid weight. The total DDT group level was 22,286 ng/g lipid weight (Fiedler et al., 2013), which clearly indicated that there could be a hidden application of DDT in those areas and that this exposed mothers to a high level of contamination.

With regard to the environmental impacts of DDT, Amera and Abate (2008), together with the NR-group carried out a rapid risk assessment and reported the following. The acute toxicity of DDT ranges from highly toxic (many arthropods and some fish) to moderately toxic (many birds, amphibians) to slightly toxic (mammals). However, acute toxicity is not often directly reflected in the field due to a variety of attenuating factors. The key issues with DDT are its persistence and its tendency to bio-concentrate and bio-accumulate[5], particularly in adipose (fatty) tissue – thus chronic exposure is the main problem. Through this process, DDT can reach toxic quantities within the bodies of animals such as birds of prey. A key issue for farmers in the rural communities is that there is a moderate to high risk of disruption to the pest/natural enemy balance within cropping systems, depending on the crop and application rates and methods, which may produce pest resurgence and the need to apply higher doses of DDT in order to maintain control of target pests. This leads to a pesticide treadmill where ever increasing amounts of pesticides have to be used to maintain some control, while at the same time, pest problems continue to increase. The higher up the food chain, the greater the increased risk. The risk of effects on bat populations may become moderate and a greater range of species of birds of prey will be at high risk. Persistence also increases, as does the risk of the insecticide getting into waterways via runoff from rainfall and irrigation. Levels of contamination of aquatic ecosystems from poor pesticide management practices (for example, spraying directly adjacent to water bodies and/or washing spray equipment in water bodies) may lead to a moderate to high risk, both to aquatic invertebrates, some species of fish and particularly to

[5] Bio-concentration and bio-accumulation refer to the buildup of the chemical within a living organism.

fish-eating birds (cormorants, terns, pelicans, herons, fishing owls, ospreys and other fish-eating birds of prey). A follow-up survey in the Central Ethiopian Rift Valley in 2015 indicated that 83% of smallholder farmers washed their spraying materials in the farrow irrigation tunnels which are connected to public water sources and also in nearby water sources (rivers and/or lakes), adding a source of contamination to the water bodies. These practices would also lead to a high risk of disruption to the ecological balance of the aquatic systems. Due to its persistence in sediment, the risk from DDT to aquatic systems will continue to increase as long as DDT continues to be applied to surrounding fields, particularly if accompanied by poor management leading to direct contamination of waterways, even if actual application rates are relatively low.

This shows the low level of understanding of smallholder farmers about a chemical that has had higher international attention for more than a decade. A reassessment is required of the way communication to and education of farmers about pesticide use and about which pesticides are allowed and banned nationally as well as internationally. Most of the training/information on pesticide use has been given by pesticide dealers and vendors. The training from pesticide dealers mainly concerns "safe" use of pesticides and how pesticides are beneficial in protecting their crops. There were few farmers that indicated that they also obtained information from agriculture extension agents. The training, however, led them to use more pesticides from time to time. Within the follow-up survey in 2015, smallholder vegetable farmers in the Central Ethiopian Rift Valley were found to be spraying tomato and onion fields at a frequency of 40 rounds per production season. When they were asked why they were doing this, they said that the market value of the vegetables they produce and the appearance of any insect in the field causes them to panic and leads them to spray an increasingly larger cocktail of pesticides. The farmers also indicated that no one had educated them about the difference between useful and harmful insects and about the availability of alternative techniques of managing pests with minimum or no pesticide use. The list of pesticides with their use within smallholder farmers in the Central Ethiopian Rift Valley is summarized in Table 10.

Table 10. Chemical pesticides widely used in the Ethiopian Rift Valley

Pesticide Group	Name of pesticide	Formulation	Uses
Insecticides	Agrothoate (Diametha)	40% EC	Bean Aphids, Thrips
	Karate	5% EC	Wide range of insects
	DDT	75% WP	Wide range of insects
	Ethiosulfan (Endosulfan)	35% EC	Bollworm
	Chlorpyrifos (Dursban)	48% EC	Termites, Stalk borer
	Ethiolation (Malathion)	50% EC	Army worm, sucking insects
	Ethiozinon (Diazinon)	60% EC	Stalk borer, soil borne insects
	Helarat	5% EC	Cutworm, Thrips, Bollworm
	Selecron	720 EC	Broad spectrum
	Decis	2.5%	Bollworm, Aphids
	Sevin (Carbaryll)	85% WP	Stalk borer, Army worm
	Profit (Like Selecron)	720 EC	Onion thrips, leafhoppers
	Polytrin	720 EC	Onion thrips, Aphids
	Deltamethrin	2.5%WP	Thrips
	Fenotrathion	50% EC	Grasshoppers, Army worm
	Nimbecidine	3G EC	Onion thrips
	Apron star	42 WS	Seed treatment
	Gelphos	440g/kg	Storage pest fumigant
	Malathion	5% dust	Maize weevil (storage)
Fungicides	Mancozeb	80% WP	Early and Late blight, Purple blotch, Downy mildew
	Ridomil	68 WG	Early and Late blight, Purple blotch, Downy mildew
	Curzate	39% WP	Early and Late blight, Purple blotch, Downy mildew
	Bayleton	25% WP	Rust, Mildew
	Bumper (Tilti)	25% EC	Rust
	Bayzomite	80% WW	Rust, Mildew
	Kocide	101	Early and Late blight, Purple blotch, Downy mildew
Herbicides	2,4-D Amine	720g	Broad leaf weeds
	U-46	720g	Broad leaf weeds
	Primagram	660 SC	On Maize for broad leaf & Grass weeds
Acaricides	Mancozeb	18%EC	Spider mites, soft bodied mites

Source: Ziway plant health clinic, 2011

6.4.3 Health impacts

Even though the majority of the farmers from the Ethiopian Rift Valley survey said that pesticides were only beneficial, 19.4% of the respondents indicated that they had experienced mixed symptoms due to mild, moderate and severe poisoning after pesticide application. All of the poisoned farmers had not been using PPE properly when they were applying pesticides and only a few attended health institutions and obtained treatment. Moreover, they indicated that they were poisoned when they were transporting, mixing, applying or storing pesticides. The chemicals they were using just before they felt the symptoms were 2,4-D (2,4-Dichlorophenoxyacetic acid), Endosulfan, Helerate (Lambda-cyhalothrin), Malathion, Mancozeb (Dithiocarbamate) and Selecron (Profenofos). In addition, most of them said that they used a mixture of these pesticides. A similar number of farmers also indicated that they have heard of mild and severe pesticide poisoning incidents (including death) in their area.

Regarding the reporting of pesticide incidents, almost all the respondents did not know the proper channel of pesticide incidence reporting and few of them said that they would report to the nearest health institution or the agriculture office. The assessment of health institutions, however, indicated that health professionals did not have proper training on how to handle pesticide poisoning incidents. It was also found that every pesticide poisoning incident was registered as being caused merely by "Malathion poisoning" without further investigation of the incident. Moreover, it had been very difficult to obtain a separate record of pesticide poisoning incidents from the outpatient records of health facilities.

6.5 Farmer Field Schools and the development of food spray as an IPM technique

6.5.1 Background of FFS in the area

The Africa Stockpiles Programme (ASP) of Ethiopia was initiated with the objective of assisting the Ethiopian government in eliminating inventoried publicly-held obsolete pesticide stockpiles and associated waste, and implementing measures to reduce and prevent future related risks. The original plan was to dispose of all inventoried obsolete pesticides and associated waste at facilities overseas. However, with the discovery of more associated wastes than originally foreseen, the project followed a blended approach of disposal overseas and lower-cost in-country safeguarding based on risk profiling of the contaminated waste, i.e. obsolete pesticides and higher risk stocks of heavily contaminated soils were to be disposed of overseas while lower risk stocks of associated waste were to be safeguarded locally. In addition, the original plan assumed zero new accumulations of obsolete pesticides during the life of the project, which was proven difficult to achieve in the context of agricultural intensification resulting in continuous new accumulations. Therefore, it was proposed that the project should develop a strategy for management and reduction of future accumulations. This initiated the first season long cotton IPM-FFS in 2006 which was implemented in Gamo Gofa Zone and phased out within a year. This previous initiative of the Ministry of Agriculture and the FAO guided the PSA to recommend a further follow-up and implementation of IPM-FFS as a grassroots means for the envisioned pesticide users' stewardship. In order to continue the feasibility of IPM-FFS, a baseline survey was conducted, which is presented in the next section.

6.5.2 Baseline Survey

A semi-structured questionnaire was used to collect qualitative and quantitative data from 107 farmers in Shelle Mella, Chano Mille and Faragossa villages in January & February 2013. This total was composed of 74.76% men and 25.24% women who participated in the baseline survey just before the setting up of the FFS.

The majority of the respondents (63.6%) said that they had not used pesticides for cotton pest control in the previous two years (before 2013) because they had stopped producing cotton as a result of a marketing problem, while the remaining 36.4% of the farmers said that they used synthetic pesticides for pest and disease control in cotton and other crop production. Of the total pesticide users, 82% used pesticides only for cotton pest control. These farmers indicated that they got 800 to 1,000 kg of cotton per hectare and the price of seed cotton was 1.50 Ethiopian Birr (ETB) (equivalent to US$ 0.10) before 2013; which forced most farmers to stop cotton farming. The price of cotton was determined by local middlemen (market brokers) who bought the cotton from farmers at a cheaper price and sold it to the central market at an increased price.

Pesticide application was usually carried out by men (fathers/sons). The farmers, however, did not know basic information about the pesticides they used, such as trade names, active ingredients, application dose and expiry dates. The types of pesticide the smallholder farmers were using, obtained from the survey, are listed in Table 11.

Table 11. List of commonly used pesticides in Chano Mille, Faragossa and Shelle Mella villages.

Pesticides	Used for
Endosulfan	African Bollworm (ABW) and aphids
Marshal (Carbosulfan)	
Deltanate (Furathiocarb)	
Dimethoate	Jassids
Talstar (Bifenthrin)	Whiteflies
Mitigan (Dicofol)	Red spider mites
Mitac (Amitraz)	
Karate (Lambda-cyhalothrin)	Complex pests
Ripcord (Cypermethrin)	
Malathion	Maize stalk borer
Endosulfan	
Detia gas (Aluminium phosphide)	Storage pests

Source: Arba Minch Plant Health Clinic, 2013

With regard to experiences in IPM, 97.2% of the respondents indicated that they had no knowledge about the existence and benefits of natural enemies. They said that they did not know about beneficial insects which were able to manage pests. They considered all insects as pests. However, a few farmers (2.8%) indicated that they had experiences of using natural enemies as pest control agents. They said that they obtained the experience from the IPM training previously given in the area.

The respondents also indicated that they used to have feelings of discomfort and illness after pesticide application. The symptoms reported by the respondents included headache, weakness, fatigue, skin irritation, loss of appetite, nausea, perspiration and restlessness. The main ill feeling after application of pesticides for many (56.4%) was headache. Other mild signs of pesticide poisoning reported by the respondents were skin irritation (48.7%), weakness (30.8%), eye irritation (23.7%), loss of appetite (17.9%) and nausea (10.3%). Moderate pesticide poisoning symptoms such as excessive salivation and vomiting (5.1%), blurring of vision, chesty feeling, difficulty of breathing and weeping (2.6%) were also reported by the respondents. The farmers also reported different pesticide poisoning incidents including deaths in the 12 months of 2012. Most of the farmers that were engaged in apiculture (29.9%) reported that the bee population was declining and they related this to the use of pesticides by smallholder farmers and commercial farms in the area.

Even if most of the respondents indicated that the role of women in the smallholder agriculture sector was similar to that of men, 6.54% of the respondents reflected that social norms prevented women from fully participating in agriculture activities. They said that women have to be engaged only in activities that are performed in the house such as cooking food, making coffee and taking care of children.

6.5.3 Consultation for setting up FFS

A consultative meeting with Addis Ababa University, PAN-Ethiopia, PAN-UK, ISD, the zonal agriculture department, zonal plant health clinic and the district agriculture extension agents was conducted so as to select villages and FFS participating farmers. Site selection was one of the important things in the establishment of farmer field schools. The FFS sites were selected by setting criteria which included cotton growing area, cooperation of the farmers, suitable meeting places, and the need of the farmers to grow cotton. It was therefore agreed to implement the FFS activities in Chano Mille, Shelle Mella and Faragossa districts of Gamo Gofa Zone. Farmers that would be involved in the FFS were selected with a thorough discussion of cotton farming communities in the abovementioned villages together with the local agriculture extension agents and the zonal plant health clinic experts. The selection of farmers was based on the interest of farmers in learning the technology, ability to participate in the season-long FFS sessions and willingness to share the experience with other famers. There was also encouragement to bring female farmers to the FFS in the first year so that it would continue in subsequent years. In addition to the criteria set to select the first regular FFS attending farmers, the sessions were announced as open to all interested farmers to join and establish their own FFS sessions in consultation with the local agriculture extension agents.

Before the beginning of the FFS, PAN-Ethiopia recruited 2 full-time field agents that had diplomas in plant protection and agronomy, the zonal agriculture department assigned 4 agriculture experts to work closely with the field agents and the three districts where the FFS were to be set up assigned one plant protection extension agent each to be part of the facilitation group in the season-long FFS.

Farmer field schools were therefore set up in three villages. The FFS was arranged with a maximum of 25-30 cotton growing farmers in each FFS site of the three villages with groups of five to six members per group to be coordinated by one lead farmer. Adjustment of the FFS sessions, introduction to the IPM-FFS materials, group formation and other issues were discussed in the introductory session of the FFS. The schedule was flexible and was open for rescheduling depending on other socio-economic and political commitments. It was decided by the farmers that the FFS days and duration were to be once a week for three hours at each FFS site. The facilitators from

PAN-Ethiopia and the zonal and local agriculture offices were following up and helping the farmers. The farmers in each group were active participants in cotton field observation and data collection. Farmers who were able to read and write were taking notes and those who were illiterate were taking part by telling their fellows what they saw so that the information could be recorded. The farmers collected both plant protection and agronomic data. Records of plant protection data included pests of different types, natural enemies, diseases and other beneficial insects. Figure 4 below shows FFS sessions in Chano Mille as an example.

Figure 4. Farmers conducting FFS on the cotton farm, Chano Mille (Photo: Tadesse Amera).

The role of the field agents and the agricultural experts during the FFS sessions had been facilitation. They facilitated and provided necessary materials, observed the groups' performance, asked why the farmers did the things they were doing and finally asked all the groups to present what they had collected/observed in the field in the form of both plant protection and agronomic data. Finally, all the farmers had to discuss and reach a decision about what had to be done next. Some might have said that irrigation was required, and some might have disagreed and said the field only needs weeding and digging, while some others might have said that it does not need anything at all; but all the proposed ideas have to be supported by justification. Finally, the farmers have to agree and decide what has to be done. The FFS was also important in helping farmers develop a habit of discussion, working together and decision making ability.

6.5.4 Food spray preparation and insect scouting training

Food spray is a natural spray product prepared from powdered maize seeds, Brewer's yeast and neem extract. Its preparation and application techniques were part of the season-long FFS training. Food spray preparation training was first given at the three FFS sites by two experts from the Organization Béninoise pour la Promotion de l'Agriculture Biologique (OBEPAB), Benin and two experts from Addis Ababa University. Since food spray had not been used previously in Ethiopia, it was first prepared by the Beninese experts who brought a certain amount of ingredients from Benin and applied in the first sessions what was finally termed as Benin food spray. They also demonstrated the methods of preparation so that the local experts would be able to prepare it by themselves in the future. The training was given to lead farmers, local agricultural extension agents, and zonal plant health clinic experts, representatives from ISD and PAN-Ethiopia staff. The participants learnt the basic principles of food spray preparation. They also prepared an Ethiopian version of food spray. Those people (including farmers) who took the first training trained other famers attending the regular FFS sessions and all the farmers attending the FFS are now able to prepare their own food spray. Figure 5 below shows the food spray preparation techniques, and how the mixing and filtering was done.

Figure 5. Food spray preparation (Photo: Tadesse Amera).

Food spray is used to attract and conserve natural enemies in the sprayed cotton field so that they can feed on and suppress the pest population below the level that the pests can damage the crops. In the FFS, three different food spray types, i.e. Benin food spray, Ethiopian food spray and neem spray were used. Benin food spray is prepared from coarsely ground maize seeds and Ethiopian food spray is prepared from brewer’s yeast, while neem spray is prepared from neem seeds. Two other food spray types were also prepared by mixing neem seed powder with maize and brewer’s yeast respectively. Food spray prepared from maize is named “Benin food spray” because it was first introduced to Ethiopia by experts from Benin, Ethiopian brewer’s yeast was also part of the trial and this was named Ethiopian food spray.

Pest and natural enemy (insect) scouting training was also given by those experts and the farmers continued to use this method to arrive at a decision on whether or not to apply food spray. Beat sheet counting of insects was the method of scouting which was the easiest for farmers and the local extension agents to implement. To obtain the ratio of natural enemies and pests, scouting was done by beat sheet counting once a week. Rows of cotton plants were randomly selected for the beating. A one meter long stick was used for beating. A one meter by 50 cm white sheet was also used for counting the falling insects when beating the cotton plants. After beating the cotton plants with the one meter long stick, pests and natural enemies that fell on the sheet, flew around and remained on the cotton were counted. For observation of small insects and counting, 20x magnification hand lenses were used by farmers and facilitators. Beat sheet counting during the first training session is indicated in Figure 6.

Figure 6. Demonstration of pest and natural enemies scouting by beat sheet courting (Photo: Tadesse Amera).

During scouting, for every beneficial insect they found, the farmers kept a "maize seed" and for every pest they kept a "stone". After sampling three 1m-long sections of the cotton crop on the farm, all of the kept maize seeds and stones are counted to determine the number of beneficial insects and pests on the crop. If "stones" outnumber "maize seeds" by more than a factor of two, then the farmers apply food spray with soap to attract more natural enemies from the surroundings so as to control pests. When it is thought appropriate, farmers and local agricultural extension agents prepare food spray and apply it to the field in the way indicated in Figure 7.

Figure 7: Farmers applying food spray during the training (Photo: Tadesse Amera).

6.5.5 Farmers as actors in change processes

The understanding of cotton producer farmers about the importance of sustainable cotton production and the negative human health and environmental impacts of pesticides was raised during the FFS sessions. The perception of farmers towards insects changed as they gained an understanding of which insects attacked their crops. They also conducted insect scouting and monitored the ratio between pest and natural enemy populations. They used food sprays if the ratio went higher than the acceptable level. By mid-2015, the total number of FFS participating villages reached 9 and the total number of participating farmers reached 2,086. One of the issues farmers repeatedly raised was concerning their previous experience of using pesticides and the consequences they faced. One of the farmers from Chano Mille recalled his experience as follows:

> I should have died when I was working in big farms and cooperatives. I used to spray dangerous pesticides dressed only in underwear (because of the hot weather) and I used to apply these pesticides on my head to eliminate head lice. I have friends who suffered from cancer, became sterile and one whose body constantly shivers so badly and who stopped long ago. I have now stopped using pesticides, along with most of my neighbors. Some of them still use pesticides on tomatoes. I plan to do a trial with food spray on my tomato crop next season. I would like this work to expand its trial plots to vegetables… We don't need financial support. We need a bit of training, some new techniques, and we can handle the rest by ourselves.

Another woman stated that:

> I stopped using pesticides in 2013 due to the perception I had that it damaged bees and livestock. I used to employ a man to spray my crops before 2013; he suffered from rashes and eye problems. Keeping pesticides in the home was a common experience. Children argued with their parents then went and drank them and died. I don't know the names of the pesticides I used to use; I put them in various containers. The most useful lesson I learned from IPM-FFS sessions is to identify farmers' friends and enemies [beneficial insects and pests]. Now many people have stopped using the nasty pesticides and bee colonies are back to our community.

It was also verified through observation of many traditional beehives hanging on trees as shown in Figure 8.

Many trees were observed in the Shelle Mella area with numerous beehives on the*m* (pictured). Local farmers say that beekeeping is coming back again after some years of decline. They attribute the improvement to the reduction in pesticide use in the area.

Figure 8.Traditional bee hives hanging from a tree in Gamo Gofa (Photo: Tadesse Amera).

When the follow-on project started in 2013, the number of farmers that were engaged in IPM-FFS was 110 in three villages. As the FFS sessions continued in the following years, it reached 222 in 2014 in similar villages and grew to 2,086 in the middle of 2015, including six more villages (Table 12).

Table 12. Number of farmers engaged in IPM-FFS from 2013-2015

No.	Village	Number of IPM-FFS engaged cotton farmers 2013 crop season			2014 crop season			2015 crop season			Remark
		M	F	T	M	F	T	M	F	T	
1	Chano Mille	33	5	38	66	10	76	252	26	278	
2	Shelle Mella	33	5	38	66	10	76	409	19	428	
3	Faragossa	29	5	34	58	12	70	102	18	120	
4	Kolla Shelle	-	-	-	-	-	-	290	22	312	New villages added in 2015
5	Zeyse Elgo	-	-	-	-	-	-	151	1	152	" "
6	Kolla Barrana	-	-	-	-	-	-	248	32	280	" "
7	Kolla Shara	-	-	-	-	-	-	183	9	192	" "
8	Kolla Mullato	-	-	-	-	-	-	154	26	180	" "
9	Genta Kenchama	-	-	-	-	-	-	136	8	144	" "
	Total	95	15	110	190	32	222	1,925	161	2,086	

The farmers are now able to identify the main pests and beneficial insects. They also know which natural enemies feed on which type of pests. They claimed that this enabled them to make better decisions when they saw insects in their cotton fields. Previously, farmers assumed that all insects on their crops were pests. Now they know how natural enemies help to maintain balance in their fields. One of the farmers expressed the situation as follows:

> This process made us experts in explaining what has been going on in our fields. We had been killing farmers' friends (they call natural enemies "farmers' friends") with synthetic pesticides considering them as pests. We are now identifying farmers' friends and farmers' enemies (they call pests "farmers' enemies"); we even know the stages of their life cycle and which stage is important to control pests.

A baseline survey on smallholder conventional cotton producers in January 2013, before the IPM-FFS project started, indicated that the yield per hectare of seed cotton was 800-1,000 Kg. After one year of IPM intervention, the yield of the IPM-FFS farmers had risen to 1,800-2,300 Kg per hectare for the 2013 cropping season, while the seed cotton yield for the 2014 and 2015 production season for IPM-FFS farmers was even greater. Cotton marketing had been a challenge for the farmers as they were obtaining low prices from the local middlemen (brokers). The price of seed cotton was 1.50 Ethiopian Birr (ETB) (equivalent to US$ 0.10) before 2013; which forced most farmers to stop cotton farming. It increased to 10 ETB (US$ 0.50) per kg in 2013 and to 16 ETB (US$ 0.80) per kg in 2014.

Taking the Shelle Mella site as an example here, and 10 ETB as the market price in 2013, we compared the net margin (profitability = total revenue from seed cotton minus costs of pest control and fertiliser application) of the use of food spray products and conventional insecticide to manage pests on cotton crops in 2013. This site was the only one suitable for comparison in 2013 because it was the only trial site that had conventional insecticide-managed cotton crops within close proximity to the food spray trial (400 m away). The seed cotton yields (kg/ha) harvested from the BFP, EFP, and neem-only treated plots at Shelle Mella were not significantly different ($P > 0.05$), but were significantly higher ($P < 0.001$) than the yields from the conventional insecticide-managed and unsprayed (control) plots. The EFP, BFP, neem-only, synthetic insecticide, and untreated control plots yielded 1,866.70 ± 66.67, 1,833.30 ± 188.19, 2,000.00 ± 157.74, 1,633.30 ± 166.67, and 1,300.00 ± 57.74 kg/ha, respectively (Table 12).

The cost of pest management and fertiliser application was highest for the conventional cotton crop (1,395 Ethiopian Birr (ETB), and was considerably lower for the BFP (85 ETB), EFP (25 ETB), neem-only (640 ETB), and untreated (zero ETB) plots. The net profit margin was highest for the neem-only treatment (19,360 ETB), followed by the EFP (18,642 ETB) and BFP (18,418 ETB) treatments. The net profits from the conventional insecticide-managed cotton and the unsprayed cotton were 14,938 and 13,000 ETB, respectively, indicating that the food spray and neem applications were more profitable than the conventional insecticide and unsprayed cotton crops (Table 13). The detailed analyses in other sites, including the 2014 result, are well described in Paper 3.

Table 13. Yields and economic returns of cotton crops managed with Benin food product (BFP), Ethiopian food product (EFP), neem extract alone, and conventional insecticides at Shelle Mella, 2013.

Treatment	Seed cotton yield (Kg/ha)	Seed cotton price (ETB/Kg)[a]	Total revenue from seed cotton (ETB)	Total pest control and fertilizer cost (ETB)	Net margin (ETB)
Benin food product (BFP)	1833.30 ± 88.19 a	10	18,333	85	18,418
Ethiopian food product (EFP)	1866.70 ± 66.67 a	10	18,667	25	18,642
Neem only	2000.00 ± 57.74 a	10	20,000	640	19,360
Conventional	1633.30 ± 66.67 b	10	16,333	1,395[b]	14,938
Unsprayed (control)	1300.00 ± 57.74 c	10	13,000	0	13,000

[a] The price of seed cotton was 10 ETB (US$1 = 19 ETB) in 2013. The price was the same for all the types because the food spray cotton was not sold with an organic premium.
[b] The pest control cost for the conventional cotton was inclusive of the costs of fertilizers that were not used in the cotton grown with the use of food spray. The yields of conventional cotton were collected from the smallholders in the study areas.

6.5.6 Farmer-led learning groups

As the farmers acted individually and without organizing themselves, they used to sell their cotton to the middlemen at low prices which were not able to compensate their production expenses. Taking this into consideration, the 2014 production season resulted in the establishment of the first organic cotton producers' cooperative in Shelle Mella, one of the project villages. The cooperative consisted of 20 members when first established in 2014. By mid-2015 the cooperative expanded by 35 additional members, reaching a total membership of 55 smallholder farmers. The cooperative is now acting as a knowledge pool for farmers from other villages and other regions. National and international researchers are working with the farmers to generate data and farmers from other localities are learning the principles of FFS and how to prepare and apply food spray from these farmers. It obtained a 200 square meter plot of land (from the local government) for office and store construction and secured an equivalent of US$10,000 from a local credit association. During the 2015 production season, the cooperative negotiated and signed an agreement with a local ginnery and received a ginning service. A total of 600 quintals (60 ton) of seed cotton was ginned with an output of 22.6 tons of lint cotton and 34.9 tons of cotton seed. The cotton seed was sold to an edible oil refining factory at an amount of 219,870 ETB (equivalent to US$ 10,470). The cotton was of grade "A" quality (through a laboratory assessment), which gave the farmers a chance to sell their cotton to the Ethiopian Industrial Inputs Enterprise (a government institution) at a price of 33 ETB (equivalent to US$ 1.57) per kilogram.

Social gatherings in rural Ethiopia particularly with smallholder farmers include traditional coffee ceremonies, church attendances, political meetings and gatherings during weddings and funerals. The weekly sessions of IPM-FFS created a stronger social tie among farmers and the discussion about their farming activities started to be extended during their social gatherings. During the weekly IPM-FFS sessions, farmers usually get the chance to walk around and assess their farm together. As an adoption of standard practice in the FFS method, at the beginning of every FFS session, farmers together call out loudly the following four guiding principles of IPM in the national language: (1) growing healthy crops; (2) conserving natural enemies; (3) observing the field on a weekly basis and (4) farmers becoming IPM experts in their field. Farmers had to be in groups of 5 to carry out all the assessments including the crop agro-ecosystem analysis. Each group had to discuss and come up with the assessment result of the farm/crop they visited and give recommendations on what was to be done next. Towards the end of the session, the different groups came together and listened to each other's decisions. All the farmers then sit together under a tree to have a question and answer session. This was a good opportunity for the farmers and facilitators to get to know each other and share experiences.

The following case story of a typical cotton farmer (with a modified name) participating in the project captures the situation effectively.

6.5.7 Case story of a cotton farmer

Mr. Bayu is a farmer living in Chano Mille village in Arba Minch Zuria district of the Gamo Gofa Zone; Southern Nations, Nationalities and Peoples region. He is a 44 year old farmer, and an 8th grade student and who has five sons and four daughters. Before 1991, he used to be a daily laborer on different farms of the area. Following the disintegration of the farmers' cooperatives in 1990, Mr. Bayu was able to secure his own plot of land in 1991. He remembers that pesticides were used only on state farms and later on introduced to smallholders through the cooperatives. The smallholder farmers were given pesticides through the organized cooperatives. There was, however, no proper training on how to use them. "*We were rather introduced to pesticides as they are medicine for our crops and we give them a local name as medicine*" said Mr. Bayu. Since a local name having the meaning of "medicine" was given to pesticides, the way they were handled, stored, mixed and applied was lacking in the care one should normally take for hazardous chemicals. Big farms were sprayed aerially and people spraying on the ground at the same time were exposed to the drift from the aerial application. This led to many people losing their lives. Cattle died, honey bees were damaged and the environment was polluted. This was, however, noted after it was too late, said Mr. Bayu.

In 2006, the Ministry of Agriculture (MoA) of Ethiopia and the Food and Agriculture Organization (FAO) initiated a season-long cotton IPM training which was part of the prevention plan of the Africa Stockpiles Program (ASP). Arba Minch Zuria district was one of the areas selected for this project, where an expert from Pakistan was brought to the area and trained about 183 cotton farmers. Mr. Bayu was one of the 183 farmers who was trained on cotton IPM for the first six months and became a farmer facilitator for another six months. He and his friends trained 560 more farmers that have been engaged in cotton IPM since then. Mr. Bayu repeatedly indicated the IPM-FFS training as a turning point in his life, which changed him and his community.

In the process of training in 2006, the Institute for Sustainable Development (ISD) was engaged in monitoring and evaluation of the training and its implementation. When the MoA and FAO phased out the project, ISD followed up the process and encouraged the farmers to continue the good work they had started. In 2013, ISD and PAN-Ethiopia took the cotton IPM-FFS project one step forward and brought new food spray technologies which meant the farmers could manage pests by using locally available, low cost and environmentally friendly means.

Mr. Bayu remembers what they were practicing before the IPM-FFS training: "Even if we knew that DDT was an internationally banned pesticide, we were using it to control agriculture pests and we were applying it to prevent storage pests, and especially to prevent weevils in maize. Our pesticide use and practices, in general, were going on haphazardly. When we saw any insect in the field, we used to feel that our crop was endangered and we did blanket spraying of pesticides. Our basis for this was that if any insect in the field was dangerous, it could mean it might destroy the crop".

He added, "We were not recording what we spent for seed and agro-chemicals, we didn't interpret the family labour, time and other related inputs into monetary terms and we were not comparing the expenses with the income we got after harvest. We did things without planning and after we harvested the crop, we sold part of it to pay for our debts and certain other expenses; and we kept some of it for consumption. This is quite different after the follow-up of IPM-FFS training and practices especially after 2013".

The 2006 IPM training and the currently ongoing project enabled the farmers to identify the morphology and names of the main cotton pests and their natural enemies.

The food spray alternative boosts natural enemies, which control major pests by natural means and in an environmentally friendly manner. Mr. Bayu explained about the ongoing IPM-FFS: "*This process made us experts to explain what has been going on in our fields. Based on this, 30 farmers have been coming to my cotton field every week for cotton IPM-FFS discussion and experience sharing. We do the pest and natural enemy counting, see the agronomic situation of the field and discuss what is to be done next. This process strengthened our social interaction and ability to deal with pest management problems so as to bring about a collective action of plant protection. Our social interaction involves coffee ceremonies, weddings, religious gatherings and funerals. At this point in time, these social* *gatherings even created spaces for discussing our farm practices, which attracted many farmers to practice what we have been doing*".

Mr. Bayu said that the environment doesn't have boundaries; the environmentally friendly work one farmer has been doing in his field can be spoiled by his/her neighboring farm. He also indicated that good quality of cotton one farmer produces may not have a good market because his produce may not fit the required quantity. He therefore advises that the practice should be disseminated to the neighboring zones and the nation as a whole for the double advantage of protecting human health and attracting a better market.

The relationship of farmers with the local government officials and experts in earlier times, according to Mr. Bayu, was not smooth. They were forced to buy inputs and their farm was visited to check what they sowed and how much they harvested for the sake of collecting taxes. He said that there was no regular visit to farms by experts and there was also no proper mechanism to advice farmers on how to apply pesticides and on how to conduct plant protection and agronomic activities. The cotton IPM-FFS, however, provided a common platform for experts and farmers to speak the same language and work together to find solutions for problems in the field. He said that no one is a teacher now except the farm and the crop. The farm and crops are miraculous teachers that change every week and give us assignments on how to act accordingly. Based on the change in the farm, he said that they discuss the next step to be carried out and this enables them to act in consensus. He repeated that there has been no more top-down forcing in the IPM-FFS. The experts have been facilitators of the discussion and they were not forcing them to follow their views, which they may not understand. Now they developed trust in each other. "*When extension agents come up with a package of promoting pesticides and fertilizers which were given to them as an assignment by the federal and regional government*", said Mr. Bayu, "*we understand them and we try to look for a mutual benefit from the process. Now we convince them that we do not need to buy pesticides for our cotton because of the effectiveness of food spray in our cotton fields. With regard to artificial fertilizers, however, some of us receive it and apply it to maize fields that are far away from the cotton fields*".

There have been a total of 161 women farmers participating at the weekly IPM-FFS and 60 of them, 20 each from Chano Mille, Faragossa and Shelle Mella, established three women's cotton spinning associations so that they could add value to the cotton to be used for traditional clothing. These three groups started getting together to spin and they sold the spun yarn to local traditional weavers and to those coming from Addis Ababa to get quality yarn. A woman farmer who is also a member of one of the spinning associations reflected on what she thinks of the process:

> I am proud of my 'white gold' and I get better yield and quality cotton like my neighboring male farmers. Cotton is something that accompanies us from cradle to grave; it welcomes us when we join this world as babies (a cotton cloth is used to wrap new-born babies), we use it daily throughout life and then it covers us on our way out of this world (a cotton shroud is used to wrap the deceased). I am appalled at the idea of this cotton being contaminated by poisonous pesticides.

The zonal agriculture department commitment that allowed the plant protection extension agents to be part of the IPM-FFS process created smooth communication between farmers and professionals. Most farmers expressed the previous communication with the extension agents as only top-down and they said that there was no chance for two-way communication. They noted that they are now experts of their own field and they receive appreciation from the extension agents. This smooth working relationship made the farmers active and enabled them to give feedback on issues that required expert explanation.

The relationship of farmers with the local government officials and experts in earlier times, according to smallholder farmers, was not smooth. The cotton IPM-FFS, however, gave a common platform for experts, farmers and others in the local government to speak the same language and work together to find solutions for problems in the field. Village administration leaders usually promoted and strove to convince farmers to implement government policies, but whenever there was an appropriate way that was feasible and helpful to the farmers, they would support it. Some of them started attending the weekly IPM-FFS and began advocating expansion to other neighbouring villages. The administrators in Shelle Mella assisted the establishment of the cooperative, facilitated the provision of land for office and store construction and recommended the cooperative to a local credit association so that it could obtain seed money to strengthen the group.

6.5.8 IPM as one means of pesticide users' stewardship

The application of alternative to synthetic pesticides has been accepted by farmers and local government institutions. It has been appreciated due to the reduction of pesticide-related human health and environmental problems. The promotion of pesticides in relation to increasing productivity has however made a complete shift in large parts of Ethiopia. The notion of "everything coming from the West is the best" and the attachment of using pesticides with "agricultural modernization" coupled with the limited technical and financial support to promote agro-ecological approaches made it difficult to make the case nationally.

The case of IPM-FFS in Gamo Gofa Zone is one of many examples in different parts of the world that show the ability to produce more while protecting human health and the environment from the impacts of pesticides. This attracted the national government and international donors; and the farmers are now encouraged to pursue on this experience. These farmers were invited to the Central Ethiopian Rift Valley to share their experiences with vegetable producers on how to use alternatives and mitigate pesticide impacts on human health. The local agriculture office in the Central Ethiopian Rift Valley area (Ziway) is convinced about this option and discussions are underway to start pilot activities in the area.

Two groups of vegetable producers from central Ethiopia and north-eastern Ethiopia were assisted by ISD to stay with farmers in Gamo Gofa for a week and learn about preparing food spray and its use for vegetable farming. Both groups are now using the technique to produce organic vegetables and they are trying to obtain organic certification. ISD in collaboration with the Ministry of Agriculture, PAN-Ethiopia and other partners is in the process of establishing the Ethiopian Association for Organic Agriculture (EAOA), which plans to adopt the IPM-FFS techniques we have been using so far.

The farmers also reported that they had around 7,000 national and international visitors that attended their field and received an explanation about their work. In addition to these, the next section describes the farmer field day events that were conducted during harvest time and the workshops conducted by the PSA.

Farmer field days

Farmers organize farmer field day events every year just before harvesting cotton. The cotton field of one lead farmer is selected and farmers, including those from other villages, organize the event. Members of the PSA, regional, zonal and district agriculture office representatives, representatives from finance and economic development from the region's zones and districts, representatives of the Charities and Societies Agency (which registers civil society organizations federally), organic certifiers and representatives of the print and electronic media attended the events.

The head of the zonal administration or someone representing the administration usually opens the event each year and the lead farmers present the processes of FFS they have been through, what they learnt from the process, the number of farmers involved, the yield they received, the market opportunity and the challenges they faced. They also demonstrate the food spray preparation and application as indicated in Figure 9, and show the cotton field to the event participants.

Figure 9. Participants visiting displays and farmer drawn posters at Shelle Mella cotton field, September 2015 (Photo: Tadesse Amera).

Women farmers and the spinning association also demonstrate hand spinning processes during field days and display finished hand spun yarns. Women add value to the cotton and produce it as yarn, which is used as a raw material/input for making traditional clothes. In addition to selling the yarn to small and micro enterprises that are working on weaving, they contracted a weaver to produce a traditional cloth called “Gabi”, which is equivalent to a thin blanket, and they sell this at around 700 ETB (equivalent to US$ 35) per piece. Figure 10 shows the method of hand spinning and display of final products.

Figure 10. Women’s spinning association members demonstrating the spinning process and showing their traditional cloth made from hand spun yarn (Photo: Tadesse Amera).

The Ethiopian Environmental Journalists Association and its media sector have been attending and covering the larger PSA level initiatives and the grassroots cotton FFS work. This also continued during field days. Moreover, the print and electronic media of the zonal, private print media attend and provide coverage of the events. The event receives national television coverage and lead farmers have been presenting their cases. The work of the women's hand spinning association was also given coverage by a widely read private newspaper.

PSA Workshops

The members of PSA followed the progress of the grassroots action-oriented result with the cotton farmers and a series of workshops being conducted in Arba Minch with the local government representatives and farmers' representatives. The main question presented to the farmers during one of the workshops was what they would do if the support from donors and PAN-Ethiopia were to stop. Their immediate reaction was that they would not stop the IPM-FFS activity. They mentioned that they had already acquired the skill of facilitation of FFS, preparation and application of food spray and moreover they had built their capacity in market negotiation and were getting better prices than they had previously. They also mentioned that the federal, regional, zonal and district agriculture offices are more supportive than before and these government institutions recognize their capacity and bring other farmers to share their experience. They even retorted by saying that "we minimized pesticide expenses and eliminated hazards, we produce quality cotton and start getting a better price, we became experts and trainers for others that do not have the skills; is there any good reason for stopping this?" The local government and the agriculture department also repeatedly showed their commitment to the initiative but requested PSA in general and PAN-Ethiopia in particular to expand this initiative widely at the zonal and regional levels; and requested the federal Ministry of Agriculture to take it as a national issue so that it could be incorporated into the national extension system. Representatives of the Ministry of Agriculture said that the ministry recognized the emergence of super pests that could not be managed by ordinary pesticides and they were internally discussing to implement IPM nationally. The Ministry also reflected on the ratification of the pesticide registration and control regulation which enforces provision for using alternatives to synthetic pesticides.

The reflection on the whole process was that when PSA started it was planning to be an autonomous institution to drive the change process in the PDS towards a notion of pesticide users' stewardship that would result in reduced and responsible use of pesticides in Ethiopian agriculture. There have been many enabling factors that promoted the initiative and which cultivate the grassroots action. The main enabling factors were: the complete agreement of all actors in the PDS about the existence of the problem and their willingness to change it, the strong support from the Ministry of Agriculture and USAID and the emergence of champion organizations such as ISD and PAN-Ethiopia, the link of the initiative with the PhD study and the involvement of SLU in Sweden in the process and the commitment of IPM-FFS farmers together with the federal, regional, zonal and district agriculture offices as well as the willingness of donors to support the IPM-FFS process.

The regulation of the Ethiopian Charities and Societies agency was one of the main disabling factors mentioned by the PSA members. As a result of this regulation, PSA cannot maintain its independence unless it holds its own organizational structure with financial and activity set up. This could not happen and PSA remained an informal initiative with its member organizations continuing the facilitation of the notion of pesticide users' stewardship. The other challenging issues for PSA are: weak post-registration system of pesticides, the special provision given to flower farms to import highly hazardous pesticides and smuggling of unregistered and hazardous pesticides over porous borders. In addition, the change process will be more challenging with the illiteracy and poverty levels of smallholder farmers.

Taking note of the enabling and disabling factors, the PSA members agreed that the local (micro) level action-oriented initiatives such as the Gamo Gofa IPM-FFS farmers can also lead to a horizontal approach of reaching other farmers and a bottom-up approach for policy influence towards the adoption of a system-wide pesticide users' stewardship.

7 Summary of Papers

The results of the study are presented in papers I to IV. The papers investigated the application of 'pesticide users' stewardship' as a concept as well as a means to address the complex pesticide situation and its effectiveness in achieving responsible management of pesticides in Ethiopian agriculture; and established the factors influencing the adoption of a system-wide pesticide stewardship network in areas prone to human health and environmental impacts of pesticides. Paper I presents grassroots pesticide-related problems as one aspect of agricultural modernization in Ethiopia in the face of stronger national and international policy frameworks on responsible use practices. The paper describes the current status of pesticide use, farmers' pesticide risk perception and the role of the main actors in the Ethiopian PDS examined as baseline knowledge towards bridging the practice gap for an 'involve-all' knowledge production in the system-wide pesticide users' stewardship endeavor. Paper II presents the process of actors' dialogues through the lens of environmental communication and discusses the supporting and inhibiting factors of the network built on stewardship as the binding concept and its potential for supporting institutional innovation and driving change towards reduced and responsible use of pesticides. Paper III demonstrates collaborative learning among grassroots farmers, government extension agents, civil society organizations and researchers who collaborated in experiments testing the innovation of alternative pest management techniques that would contribute practical agro-ecological solutions for the overarching goal of pesticide users' stewardship. This collaborative learning process examined the application of a supplementary food product to conventional cotton crops and proved that it attracted, sustained and increased the abundance of beneficial insects and demonstrated that these beneficial insects managed pests effectively on cotton crops under Ethiopian conditions. Specifically, during the study a new food spray product, Ethiopian food product (EFP), was developed from ingredients available locally in Ethiopia and was compared with food spray products tested in Benin. Paper IV assesses the feasibility of FFS as a means of transformative learning and an effective approach to apply the notion of pesticide users' stewardship in smallholder cotton farming at local level; and investigates the enabling and disabling factors towards the feasibility of pesticide users' stewardship-led change in policy and practice to address the pesticide problem. The summary of each paper is presented in the following four sections.

7.1 Paper I: Pesticide risk perception among farmers in the Ethiopian Rift Valley and challenges for effective risk communication

This paper describes the existing pesticide risk perception and challenges of effective risk communication among smallholder farmers in the Ethiopian Rift Valley. Pesticide use and practices by smallholder farmers is a primary source of pesticide hazards to human health in Africa (Gockowski and Ndoumbé, 2004; Sibanda et al., 2000; Matthews et al., 2003; Ngowi et al., 2007) and the situation is similar in Ethiopia (Mekonnen and Agonafir, 2002; Williamson et al., 2008). The main means to mitigate this has been different forms of training provided by agriculture extension agents and the pesticide industry, but this has not managed to yield the required result by farmers (Matthews, 2008; Mekonnen and Agonafir, 2002; Williamson et al., 2008). Farmers' risk perception is directly related to their beliefs, attitudes, interpretations and judgments about the risk (Breakwell, 2000; Pidgeon, 1998).

Quantitative and qualitative methods of data collection were used to gather information from 1,259 farmers. For the quantitative survey, a semi-structured, interviewer-administered questionnaire was used from 2008-2012. For the qualitative part of the data collection, farmers were asked open-ended questions and additional observations were made in the field by the first author as primary researcher. Pesticide poisoning cases reported by interviewees were recorded and compiled separately.

The study found that 50% of the farmers were not using proper personal protective equipment (PPE), used empty pesticide containers for storing food and drink, stored pesticides at home in the kitchen and did not follow the instructions provided on pesticide container labels. An internationally banned chemical, Dichloro-Diphenyl-Trichloroethane (DDT), was also found to be used for agriculture pest control purposes. Many acute, mild and severe pesticide incidents were also reported.

Widespread mismatch is observed between farmers' understanding of the benefits of pesticides and the health risks and associated economic costs. This is attributed to the flaws of agricultural modernization as the dominant paradigm and a fragmented national policy that framed pesticides only as important tools for agriculture productivity without giving due attention to their human and environmental impacts. These aspects are usually countered by labels on pesticide containers, but these often do not consider the illiteracy and local situations of smallholder farmers. This paper assessed the risk mitigation attempts by different actors in the PDS and investigated the main gap between policy and practice. A top-down linear approach of pesticide promotion and "safety" training is the main approach that has been used by the government extension agents and others in the PDS to mitigate the problem. The paper revealed the need for a different approach to deal with this complex problem and provided baseline evidence of the current situation to actors in the PDS and emphasized the need for reframing of the pesticide situation in Ethiopia and the importance of all actors (including end users) to be part of the knowledge production process in an attempt towards a system-wide pesticide users' stewardship in Ethiopian agriculture.

7.2 Paper II: Innovation platforms for Institutional change: the case of Pesticide Stewardship Network in the Ethiopian Rift Valley

This paper examined the supporting and inhibiting factors of the network built on stewardship as the binding concept and its potential for supporting institutional innovation and driving change towards reduced and responsible use of pesticides. Actors in the Ethiopian PDS appreciated the gravity of pesticide problems and established a network of actors. This first attempt of institutional and organizational change was perceived as an innovation (Nederlof and Pyburn, 2012). The actors that perceived the problem created a dialogue forum and conducted meetings/platforms (Röling, 1994) and continued looking for solutions to the perceived problem.

A participatory action research (Brannick and Coghlan, 2010) methodology was used to document and analyse the discussion processes. The cyclic process of planning, taking action, evaluation of the actions (which leads to further planning and more iterations of the cycle) assisted the study to follow the discussions and actions of the pesticide stewardship initiative in Ethiopia. The process appreciates the Systemic Action Research process resulting in learning through reflection at different levels, within and among the institutions and individuals involved in the research process (Arévalo et al., 2010).

The pesticide stewardship network initiative began its dialogue by allowing the presentation of all the benefits of pesticides in Ethiopian agriculture since its introduction as a migratory pest management tool; and experiences on the human health and environmental impacts of pesticides in Ethiopian agriculture. As PSA at federal level has been composed of governmental and non-governmental organization experts, academia, researchers and policy makers, the forum was ideal in presenting science-based evidence both on the benefits and hazards of pesticides in Ethiopian agriculture. This Mode 1 knowledge production (Gibbons, 2000) has been essential to establish existing facts that would convince all actors in the PDS, and this was also taken to regional and local level events. As a result, all the presentations on the benefits of pesticides and the negative impacts they brought were not objected to by the actors in the PDS, including representatives of the pesticide industry. Taking note of the benefits in plant protection, the question that was presented was whether there was willingness to work together to mitigate the negative impacts.

The actors in the PDS, therefore, fully agreed on the existence of a pesticide problem and commenced work on the establishment of a system-wide pesticide stewardship network. This process resulted in the establishment of the Pesticide Stewardship Association (PSA), which brought all actors on board to share the notion of pesticide users' stewardship in their pesticide-related work. This process did not face challenges of conflict of interest from different actors because it did not approach the situation with the promotion of a negative and extreme view about pesticides. It rather showed evidence of the problems and requested a concerted effort to mitigate them.

This innovative process resulted in other institutional and technological innovations at local and regional level, which are presented in papers III and IV. However, the higher level initiative faced a challenge of formality because of the national regulations. It was obliged to have its own office, organizational structure, financial and administrative manual and grassroots project implementation plan, as well as records of accomplishments. This stringent regulations and formal requirement of the state became restrictive to the mode of operation of the self-organized entity. The members, therefore, decided to keep it as an informal network to be facilitated by one or more of the member organisations in the PDS and to continue working on the realisation of pesticide users' stewardship at local and regional level. This was well implemented by member organizations and the federal level initiative is now functioning as an informal network.

7.3 Paper III: Integrated pest management in a cotton-growing area in the Southern Rift Valley region of Ethiopia: Development and application of a supplementary food spray product to manage pests and beneficial insects

The costs of inputs and pesticide impacts in cotton production have risen sharply and become a significant burden to many smallholder cotton-farming families, particularly in Africa (PAN-UK, 2009). Given the importance of reducing the negative impacts on human health and the environment of agrochemicals, cotton production that employs environmentally-friendly and natural methods has recently attracted attention following some positive results in the development of alternative pest management options involving semiochemicals and biopesticides (Mensah et al., 2013a).

An experiment was conducted on the cotton fields of smallholder farmers in the villages of Shella Mella, Chano Mille and Faragossa in the Gamo Gofa Zone. A pre-treatment of dry cow manure was applied to the fields before the cotton seed was planted. Deltapine 90 (DP 90) cotton seeds (provided by the Cotton Research Institute in Melka Werer, Ethiopia), which are widely used in the Ethiopian cotton industry, were planted at all the study sites. Six different treatments were applied in six randomized complete block design plots and evaluated for the results.

The results show that applications of supplementary food spray products can boost the densities of beneficial insects (particularly predatory insects) that are useful for managing pests in cotton fields, which is a similar finding to other studies (Mensah et al., 2012; Slosser et al., 2000). Mensah and Singleton (2003) also reported that supplementary food spray products could conserve beneficial insects in sprayed cotton fields. In this study, the presence of predators attracted to the supplementary food products was sufficient to maintain pest numbers below the economic threshold level, resulting in higher crop yields and better net margins for the farmers compared to those for conventional insecticide-managed fields (Mensah and Singleton, 2003). Food spray products were applied after visual survey results revealed a predator-to-pest ratio of below 0.5 per metre (Mensah, 2002). Regular monitoring of the predator-to-pest ratio also has implications for reducing the costs of preparing and using food spray products; i.e., the food spray products only need to be prepared and applied when the predator-to-pest ratio is less than 0.5.

This process involved a collaborative learning process; participation of members of PSA, particularly experts from federal, regional, zonal and local agriculture offices, national researchers from Addis Ababa and Hawassa Universities, the Institute for Biodiversity Conservation, civil society organizations and smallholder cotton farmers from the three villages. The farmers were very active in the hands-on, action-oriented technological (alternative pest management) innovation and were very articulate while being involved in the Mode 2 form of knowledge production (Gibbons et al., 2000) which has been adopted by hundreds of neighboring farmers and has demonstrated substantial reduction in pesticide use and its impacts. This being the local situation, however, the adoption of the innovated technology in crops other than cotton and more areas than the first trial area has to be followed up and documented.

7.4 Paper 4: Farmer Field Schools as means of System-wide pesticide stewardship: the case of smallholder cotton farmers in the Ethiopian Rift Valley

Pesticides, introduced as a means of increasing productivity, showed the decline of the promised efficiency and efficacy in the 1980s with the emergence of pesticide-resistant pests, which led to the introduction of Integrated Pest Management (IPM) through a Farmer Field School (FFS) approach, mainly in Asia (Untung, 1996).

The smallholder farmers' FFS research process was guided by participatory action research (Dick, 1997) as the main philosophy and methodology to reveal local grassroots action, which itself emerged as the outcome of higher level policy dialogues. Participatory workshops at different levels of the PDS, a baseline survey before setting up FFS, and FFS as a participatory method of learning, technology development and dissemination based on experiential learning (Davis and Place, 2003) were used as methods of qualitative and quantitative data collection.

The farmers in the IPM-FFS acquired the necessary skills to identify pests and beneficial insects, reduced pesticide use in cotton, increased cotton yield and obtained a cotton price increment in local and national markets. They also realised their role in the development process, appreciated the power shift in the farming system and started evaluating the process and inviting others to join. An organic cotton producing cooperative and three traditional women's hand spinning associations were established and linked themselves to income-generating activities in relation to cotton production.

The Ethiopian experience of cotton IPM-FFs showed a reduction in the amount of pesticide use amongst smallholder farmers, which was similar to studies in Asia (Kenmore, 1996; Untung, 1996) and other parts of Africa (Simpson and Owens, 2002). The level of farmers' empowerment, the actions of farmer-to-farmer communication and the opportunities created for women to actively participate in the FFS sessions were similar to earlier FFS implementations in India and East and West Africa (Davis et al., 2012; Mancini et al., 2007). It also demonstrated the potential of the approach to serve as a model for grassroots-based action that could feed towards a system-wide pesticide users' stewardship aimed at reduced and responsible utilization of pesticides in Ethiopian agriculture.

This process demonstrated the field-based planning of pest management techniques, with a typical model of the action research approach involving taking appropriate steps in the cotton field, evaluation of what has been done and changed in weekly sessions of the FFS, re-planning of the next steps in the season-long process and reiteration of the cycle. The opportunities and challenges of the social, cultural and institutional settings in the intricate interaction of actors in the co-production of knowledge, its utilization and attempts at dissemination to other areas in Ethiopia have been evaluated (Best and Holmes, 2010; Glasgow and Emmons, 2007; Green et al., 2009).

The collaborative learning process that incorporated other actors within FFS assisted in looking into gaps between theory and practice in the conventional agriculture settings and created a space for transformative learning through co-production of knowledge and availed knowledge from research and knowledge from practice simultaneously (Van de Ven, 2007; Van de Ven and Johnson, 2006). Investigating how knowledge from both can be transferred and whether the national policy framework buys the idea of utilising knowledge from both to fill the gap between policy and practice, and as a contributor towards a system-wide pesticide users' stewardship, will be the main task of PSA in the future.

8 Discussion and conclusion

This chapter is a discussion of the main findings approached along the lines of three broad thematic questions which overlap with the main research questions. The relationship between these questions, the conceptual foundation to the work and the four papers are outlined in Table 14.

Table 14. Discussion approach

Research focus	Key questions	Concepts	Evidence/Findings	Research Sub-questions	Paper
Reframing pesticide risk in Agricultural Modernization	What are the factors that are making the Ethiopian farmers and farm workers vulnerable to risky use of agro-chemicals?	Framing, Risk communication, knowledge production	History Regulation Secondary data Case stories Interviews Technicians	I	I, III & IV
Institutional innovation, and space for change	Which institutional factors enabled farmers' agency to act in that social space?	Institutional Innovation	Workshops Focus group discussions Observations Institutional maps	II	II,III & IV
Stewardship behavior & change through knowledge production	What are the important behavioral aspects of farmers indicative of stewardship in their application of IPM alternative in their farming practices?	Transformative learning & Stewardship	FFS data Field log book Food spray data Workshops Farmer interviews Workshop reports PSA progress International experience	I & II	III & IV

8.1 Reframing Pesticide Risk in Agricultural Modernization

Agricultural modernization is claimed to be successful in development and maintenance of soil fertility; mechanizing agriculture and producing more, improving genetics for crops and livestock to enhance yields, quality and reliability, and protecting plants and livestock from losses to competing plants, diseases, insects and other threats through modern genetic techniques and chemical application (Motes, 2010). The complex applications go from producing renewable energy, which attracted complaints concerning competing food production, the promotion of genetically modified seeds, which are also claimed to curtail rights of farmers to seed varieties and to contaminate indigenous genetic resources, to the well-discussed agrochemical use and its consequences which drove enlightened governments to formulate policies of environmental stewardship.

Broad spectrum pesticides are purposely applied to the environment to kill wildlife in order to protect agricultural and industrial products. The risk associated with their unintended impact should also be handled with due emphasis as it has been for its benefits. Risk, according to Ulrich Beck, is an inescapable structural condition of the way humans have progressed through modernization, and we live in a world risk society (Beck, 2006). An understanding of the complex whole as well as of the interconnected parts of that whole, the essence of a systemic approach to managing pesticide risk in society, creation of alliances among those important parts that make up the system, and adequate articulation of risk across those parts through a multi-disciplinary approach are ways in which this study has attempted to handle the pesticide question in Ethiopia.

As in many other parts of the world, Ethiopia has also been the "beneficiary" of pesticide use, especially in controlling swarms of different types of transboundary migratory pests and during the emergence of large and mechanized state farms in 1970s until the recent development of flower farms. Even though the benefits of agriculture modernization and especially those of pesticides gain more coverage, the consequences of their impacts on human health and the environment was and still is not sufficiently communicated. With regard to pesticide use and its consequences, studies have shown that a very high proportion of farmers and agricultural workers exposed to pesticides are suffering acute health effects. These acute health impacts were revealed in 100% of women picking cotton after pesticides were sprayed in Pakistan, in 85% of applicators in Bangladesh, in 82% of farmers in Burkina Faso and in 45% of agricultural workers in Brazil (Watts and Williamson, 2015). Explaining this in monetary terms, UNEP's (2013) "Cost of inaction" report estimated that the accumulated health costs of acute injury alone to smallholder pesticide users in sub-Saharan Africa would be approximately US $97 billion by 2020 (UNEP, 2013 (b)).

Apart from the transfer of modern agricultural tools such as pesticides to developing countries like Ethiopia, the way in which the associated risks are communicated to the end user community has not kept pace with similar processes in developed countries. The debate on the pros and cons of pesticide use is still continuing, but the development policy and short and long term strategic plans of Ethiopia still focus on high input agriculture (FDRE(b), 2010). Contrary to this conventional move, the FAO Director-General, José Graziano da Silva, said in his 2015 speech in Paris that "The model of agricultural production that predominates today is not suitable for the new food security challenges of the 21st century. […] Since food production is not a sufficient condition for food security, it means that the way we are producing is no longer acceptable" (Watts and Williamson, 2015). Unlike Cochrane's agriculture treadmill (1958), Ethiopia faces a different version of it from ecological disturbances associated with agricultural modernization leading to more pest problems, soil degradation and recurrent drought (Cochrane, 1958). Moreover, the human health and environmental impacts of pesticides that are assessed as part of this thesis and by other researchers in previous years (Mekonnen and Agonafir, 2002, Williamson et al., 2008) have been experienced in other parts of the world (Sherwood, 2009). The Ethiopian Ministry of Agriculture, however, realized the gravity of the problem and became a major actor in PSA and facilitated the process of dialogues on how to reframe pesticide benefits with its risks in a way that would be a basis for a system-wide pesticide users' stewardship.

The use of wide spectrum pesticides disrupt natural mechanisms of pest management and as indicated in chapter 3, the Ethiopian Ministry of Agriculture was recently faced with newer super pests such as cotton mealybug (*Phenacoccus solenopsis*) which threatened the Ethiopian cotton farming system and the larvae of the moth, *Tuta absoluta*, which nearly caused the disappearance of the tomato from Ethiopia. Both pests had never previously been reported in Ethiopia and when they emerged, no pesticide was able to control them. Even for usual pests that vegetable farmers faced in the Central Rift Valley of Ethiopia (as indicated in Chapter 6 and Paper I), they apply pesticides up to 40 rounds in one production season, which is a classic example of the pesticide treadmill (Van Den Bosch, 1977). Studies in other parts of the world also show proliferation of more pests and diseases, including the emergence of secondary pests that would cause more trouble than the pests the chemicals were originally designed to control (Dover, 1985, Poswal and Williamson, 1998; Sherwood, 2009). The contamination of water, harm posed to wildlife and hazards to human health caused by pesticides are mostly externalized and less accounted for (Altieri, 1995; Conway and Pretty, 1991; Pretty, 1999; Pretty et al., 2001; Pretty, 1995; Sherwood, 2009).

This thesis set out to describe pesticide use and related risks in the current farming practices in Ethiopia, as well as to gauge farmers' pesticide risk perception so as to understand the missing link in the current muddled situation. Chemical pest control has been the method of choice for most farmers in the study areas, and it is evident that there is a wide gap between farmers' understanding of the benefits of pesticides and that of associated health risks and their toxic nature (Mekonnen and Agonafir, 2002; Williamson et al., 2008). The low level of understanding of pesticide risk among farmers was reflected in their belief that the production benefits outweighed the hidden impacts on human health and the environment. Most of the attempts at pesticide risk reduction are based on training and provision of labels and pictograms. However, the training given by agriculture extension agents and the pesticide industry has not been able to bring about the intended practice. The industry's approach to risk communication is one that is universally applied and is built on a business strategy based on providing labels, instructions and pictograms simply to transfer the liability to end user farmers. A farmer that does not follow the label or pictogram and faces pesticide poisoning is herself/himself accountable, regardless of her/his level of literacy, state of health or the environment to which s/he has been exposed (Ríos-González et al., 2013; Rother, 2011b).

One of the main reasons for the mismatch between the training and practices could be the framing of pesticide use with high productivity/gain; and reduced/no-use with less productivity/loss. Tackling this mismatch requires reframing of the pesticide issue starting from the policy framework, and there should be policy-directed cascading of the reframed issue in such a way that it can mitigate the lingering pesticide problem in Ethiopian agriculture. The framing of pesticides by farmers as "medicine" played a great role in the way they were handled, from storing it with foodstuffs and using pesticide containers for food and drink storage, to applying pesticides for human and animal ecto-parasite treatment. Reframing of the original mis-framed issue will provide a way to soften "the power of a frame which has been as great as that of the language itself", as Entman states (Entman, 1993).

A second issue requiring special attention is the top-down flow of pesticide-related scientific evidence which may not work for the local situation. A pesticide tested in a Western laboratory with consideration of a "Caucasian healthy male" as an applicator, requires a different risk assessment data for application by non-Caucasian end users (who could possibly be women or unhealthy men) in a tropical setting (Rother, 2011b). Moreover, in addition to the conventional approach of the national government in adopting international conventions into national policy frameworks and regulations which have never served to bring the required pesticide risk mitigation, it also relies much on pesticide risk communication as a public relation strategy magnifying the economic benefit of pesticides which is in line with industry's business strategy of repeating the use of labels, instructions and pictograms (Paper I). This conventional approach of delivering labels and instructions mainly helped the industry to escape litigation, but brought little or no protection to the end user smallholder farmers from the hazardous impacts of pesticides, as it claimed it would. This does not mean that labels, instructions and pictograms are irrelevant, but that their usefulness did not sufficiently reach the small-holder farmers. Training was provided, but did not deliver the required behavior change. Pictograms intended to comprehend risks associated with certain practices/malpractices, for example, were found to be ineffective in bringing a clear understanding to farmers, and in some cases they were even misinterpreted and led farmers to engage in more risky behavior (Rother, 2008, Viviana Waichman et al., 2007).

This, coupled with the deficits in the health support system in terms of lack of proper channels for handling, registering and reporting incidences of pesticide poisoning, indicate the wider context of the problem of pesticide risk perception in society and the magnitude of associated social costs. It can be attributed to lack of coordination between experts and practitioners to work with grassroots farmers in generating knowledge that considers the local context for building multiple-accountability in the agriculture sector of Ethiopia. Addressing this gap will benefit future initiatives to deal with the wicked pesticide problem in a non-linear approach of knowledge production that would be used as one approach to assist science-policy dialogue that leads to mitigation of the problem (Nowotny et al., 2003: Sarewitz and Pielke, 2007).

The current policy model in place with regard to pesticide regulation in the public sector in Ethiopia is similar to what is seen in most developing countries; an example of a system governed by linear and mechanistic thinking which considers the local context as irrelevant, while systematically ignoring all the unintended consequences instead of learning from them. I qualify the above as a case of 'system failure' (Chapman, 2004) or 'systemic failure' (Reynolds, 2014). Failure here in simple terms implies the inability to see the interconnected nature of things in the world. This calls for a more holistic or systemic approach which moves away from the command, control and predictability that characterize the present model, and towards one that recognizes the interconnections and the big picture. The multiple perspectives held by the different actors in the system will not only be acknowledged but provide the means to engage them through active processes of social learning and communication. The adaptive capacity derived from such a systemic approach would enable the PDS to accommodate the complexity, uncertainty and ambiguity inherent in the challenge of pest and pesticide management in the farming sector and go a fair way towards addressing the shortfall in systems orientation recognized within the field of crop protection (Schut et al., 2014).

In line with this, pesticide risk communication should consider two-way communication rather than a top-down "do" and "do not do" kind of command, as found in many of the practices of extension agents' training indicated in Paper I. The organizational capacity in handling pesticide risk communication and the conventional framing of pesticides in Ethiopian agriculture are centers of concern in this process. Habermas' communicative learning emphasizes the need for understanding the meaning of what is communicated, self-skills, sensitivities, and insights with an open mind so as "*to arrive at the best judgment"*(Habermas, 1981). This, however, requires a learning space which brings trans-disciplinary actors for knowledge co-production in the muddled realm of pesticide use, practice and associated benefits and problems. Such spaces, in both a physical and abstract sense, have been referred to as *Community Agoras* (Hansen et al., 2016). These are important for all actors to come together and evaluate what has worked well, what has not worked, the reasons for this and how to mitigate/solve the pesticide problem in Ethiopian agriculture. The creation of this dialogue space among all actors in the PDS at national, regional and local levels, which will be discussed in the following sections, was with a view to bridging these gaps so as to reach a shared understanding of the benefits and risks of pesticides and how to mitigate the risks. A significant step forward in devising a more participatory, interactive and involve-all knowledge co-production is required to attain the envisioned level of pesticide risk management.

This process strengthened the case for further discussing the need for action-oriented, policy-directed dialogue that can lead to an understanding of and subsequent action ground the socio-economic, politico-cultural and organizational settings and their features that have hindered the realization of effective pesticide risk communication. This, however, requires interactive communication (Leeuwis, 2000) which could be reached through establishment of trans-disciplinary interaction at national level that creates a space for social learning in order to bring individual and collective cognitive changes at all levels and build capacities of actors for the envisioned change process. The level of poverty and extent of illiteracy of smallholder farmers are amongst the main factors that should be considered when planning knowledge co-production and pesticide risk communication. The well-established national extension program of the Ethiopian agriculture system can be taken as an opportunity for further investigation of underlying factors that are making the Ethiopian farmers vulnerable to risky use of pesticides and moving towards extension practice that share features demonstrated in this study with farmers in Arba Minch (Paper IV). However, a cautionary note here would be that the extension program has remained as part of the very same system trapped within the conventional worldviews and practices of framing pesticide use as the main agent of modernity in cascading it to grassroots farmers. The formidable challenge of tackling this falls on national and system-wide initiatives of the kind experimented within this study via the PSA.

8.2 Institutional innovation and space for change

Innovation platforms in this thesis are seen as support for agricultural institutional innovation that facilitates technological, social and economic change through the notion of an ethic of pesticide stewardship as a guiding principle to all actors in the PDS. The human health and environmental impacts of pesticides in Ethiopian agriculture initiated a problem-*driven* (Van Paassen et al., 2014) initiative, establishing a dialogue forum that incorporates all actors with divergent interests in the Ethiopian PDS. The unique approach of this initiative was recognizing and appreciating the contribution of pesticides and pesticide-related policies in the national development process and presenting the unaccounted for human health and environmental impacts that may hinder the development process. The approach was not from a purely natural resource management or conservation perspective, which usually creates conflict amongst actors with divergent interests. Rather, this process emphasized the unplanned *side-effects* of pesticides in the development process, which required participatory policy formulation (Aarts and Leeuwis, 2010). This thesis is therefore built on the examination of a networking approach to institutional innovation attempted at three levels connected to pesticide management in Ethiopia; at meta (national), meso (regional) and micro (local) levels.

At the meta level, the actors in the pesticide delivery system ranging from experts and policy makers, researchers, pesticide producers, importers and distributers, civil society and the private sector with divergent interests, came together for the first time to discuss and act on the environmental and human health impacts of pesticides in Ethiopian agriculture (Paper II). The discussion was not about whether or not pesticides were important to the agriculture sector; rather it focused on the unintended impacts that they were causing and called for a concerted effort of all the actors in the PDS. Many initiatives that focus on conservation of natural resources with a proposed suggestion of limiting and/or avoiding pesticide use, as well as initiatives that require extra expense that some stakeholders may not be able to afford, have resulted in failure. Among the reasons for the failure of participation in the innovation attempts indicated in some studies include predetermination of policies of interest by the government, which marginalizes main non-state actors, unbalanced power relations in the dialogue process, emergence of unplanned outcomes, a time-consuming dialogue process and the complexity and unpredictability of results (Aarts and Leeuwis, 2010; Aarts et al., 2007; Cleaver and Toner, 2006; Turnhout et al., 2010; Van Bommel et al., 2009). Unpredictability of the results in policy dialogues of the Ethiopian PDS is still an issue. However, none of the actors, including the industry, objected to the existence of the problem and everyone was willing to participate in the process. Voluntary participation was a notable feature throughout the entire work, driven by a strong recognition of the extent of the problem, or crisis even. This was far more pronounced at the national level, clearly due to the level of education and expertise among the specialist actors with organizational backgrounds. A remarkable distinction here would be the case of the industry representative, working for Crop Life Ethiopia, who indicated that he himself had been witness to too many pesticide incidences in his previous work experience while working as the head of a state farm, which led him to join the voice of others to work together to mitigate the problem and drive for pesticide users' stewardship. This is an initiative that had never been tried before and which continued facilitating policy dialogue among actors in the PDS. The dialogue process, therefore, revealed the felt need for institutional innovation (Woodhill, 2010) built on stewardship as the binding concept and its potential for driving change towards reduced and responsible use of pesticides.

The acknowledgment of "Pesticide users' stewardship" among actors in the different organizations of the PDS is the first step taken by PSA as a guiding principle. It has been my contention here that the PSA, as the main link to the meso and micro level action of the process has been acting as an innovation platform enabling institutional change (Ayre et al., 2014), particularly at the micro level. The attempt at institutional change has been towards changes in practice at respective levels of the PDS which was envisioned to result in a visible outcome, with reduced and responsible use of pesticides so as to mitigate the human health impact. In order to attain the required practical level change, the dialogue forums with those who perceived the problem and agreed to solve it (Röling, 1994) paved the way. However, the willingness of actors to work towards the same goal and the establishment of PSA in its desired level of effectiveness at the national level was hampered by formal requirements imposed on it by State regulations. The national regulation which obliged initiatives like PSA to have their own organisational structure, office, financial system, programme operations and reporting channels, all became obstacles for PSA to proceed as a formal organisation (Paper II). The immediate option taken by network members of PSA was to remain as informal as possible, without seeking a formal national status, and to continue the initiative in strengthening actions at regional and local levels. The flexibility and openness associated with bridging or intermediary organisations as reported in the context of adaptive management literature are features that PSA could have acknowledged and incorporated in the choice of its organisational form, status and performance (Green et al., 2015). There might come a time in the future when PSA can obtain the necessary financial resources to lift itself up to a formal national platform status, working on the original notion of pesticide users' stewardship.

However, experiences show that institutional platforms that overcome these types of challenges, including participation and action, also face different problems. Some donor-funded innovations have failed to sustain themselves, while others have succeeded (Biggs, 2007; Röling et al., 2014). There is no guarantee that PSA will be sustainable, even if it maintains the required financial and organizational structure. Such types of innovation platforms in developing countries are usually considered weak (Szogs, 2008). One way to keep the momentum of PSA and to maintain its sustainability and strengthen the innovative processes, is to maintain the already-engaged active intermediary organizations and also the existing linkages between different actors (Klerkx et al., 2009; Klerkx and Leeuwis, 2008).

The dialogue forums on pesticide risk perception and risk communication at meso (regional) level created by PSA gave a chance for all actors at the grassroots level to bring out the actual situation of pesticide problems and to propose their ideas on how to mitigate them. This was different from the conventional forum the grassroots actors had had previously. They used to talk about the benefit they obtained from using pesticides and the production difference achieved compared to previous years. The possibility to discuss the negative impacts of pesticides with officials of the Ministry of Agriculture, representatives of the pesticide industry and researchers from universities was a significant step which the regional actors had not expected. This process laid the foundation for internalization of the notion of "Ethic of pesticide users' stewardship" as a rule (Ruttan, 1989) and was assisted by organizations and individuals who dedicated themselves as innovation intermediaries/innovation brokers (Howells, 2006; Kilelu et al., 2011; Röling, 1994). As Cees Leeuwis puts it, innovation is not just a new technical product or procedure created in research facilities; it is rather a novel working whole, a novel pattern of coordination and adjustment between people, technical devices and natural phenomena (Leeuwis, 2010). However, the findings reported from this study at the regional level are limited only to appreciating the existence of pesticide-related problems and noting the actual gap between pesticide-related training, labels, pictograms and discussions; and the actual practice on the ground.

The agriculture extension system through extension agents had been traditional intermediaries in supporting agriculture innovation, particularly in transferring technology and knowledge to farmers in the Ethiopian situation as everywhere else. However, its effectiveness has been questioned for its linear approach and lack of broad systemic support beyond knowledge generation and use to include forging links and interactions among diverse actors (Kilelu et al., 2011). The creation of this dialogue forum as a social space for change can be taken as a positive aspect of the process which can involve the agriculture extension system in trans-disciplinary action-oriented knowledge production supported by policy and the Ministry of Agriculture. If this becomes part of the extension system in the Ministry, it may support the development process, brokering innovation beyond increasing the supply of new scientific knowledge and technologies by creating a space for interaction between scientific, technological, socio-economic, institutional and organizational arrangements (Smits, 2002).

The micro (local) level dialogue with smallholder cotton producers in the Southern Ethiopian Rift Valley area initiated the establishment of the first cotton producers' cooperative and the women's hand spinners association. The participatory approach created a space for these platforms to critically reflect on their interaction. This was advantageous particularly in laying the foundation for a collaborative learning and non-hierarchical approach where the farmers feel ownership of the process. Their direct involvement in planning, developing, implementing and evaluating the learning experiences encouraged them to critically reflect on the process, comparing the new approach with their past routines. Similar experiences in Kenya also showed transformation of farmers to betterment, more involvement of women in the FFS process, improved community relationships, and development of the subsistence farming to business (Duveskog, 2013). The higher level coordination of actors with divergent interests (Suchman, 2002) has been an important step in the linked meta-meso-micro action of the pesticide stewardship process. PSA as an innovation platform initiated socio-technical change (the alternative pest management practice presented in paper III), organized a new social arrangement of cooperatives through FFS (Paper IV) at local level and continued to take lessons from the whole process.

The Ethiopian textile industry currently suffers from an insufficient supply of cotton, and it is importing lint cotton from other countries. The organization of cooperatives in this area and especially the interest of farmers to produce organic cotton were encouraged by the textile sector. The industry has already started buying cotton directly from the farmers; however, the focus is only on the final product rather than assisting the farmers in the production process. This should therefore be backed by strong policy support in laying foundations that support the organic support system and encouraging other neighboring farmers with agro-ecological farming that minimizes cross-contamination of products. As has been witnessed in the area, the experience of IPM-FFS attracts more neighboring farmers and farmers from other regions to come and learn from this local experience (Paper IV). The local and national government should therefore encourage the continued farmers' interest to "*learn from others*"; and support the already empowered lead farmers who are facilitating the learning process, in the manner of "*learning by doing*" (Spielman et al., 2011), with a weekly FFS regular engagement of farmers and practitioners in the experiential learning process of linking themselves to their work and personal development in groups and individually (Kolb, 1984).

8.3 Stewardship behavior & Change through knowledge production

The historical and cultural settings of Ethiopia, the importance of formal and informal education, the social hierarchy and its implication in the learning process as well as the political setting and implementation of international and national policies frame the adoption of the notion of ethic of pesticide users' stewardship at different levels. As the Ethiopian policy framework does not provide incentives for environmental stewardship such as found in the EU (Dobbs and Pretty, 2004; Quillérou and Fraser, 2010), the initiative emanated from a voluntary, human-centered approach of motivation and dedication (Ryan et al., 2001) of federal level actors that led the grassroots actors to act voluntarily. The policy-practice interface can, therefore, be handled in a consultative rather than confrontational approach which will result in rewarding the multi-level actors by reducing the negative impacts of pesticides on human health and the environment.

In addition to the regular use of pesticides, accumulation of obsolete stockpiles has also been a major problem in many countries. A recent report of USAID/OFDA (2016) indicated the existence of obsolete stocks for locust control pesticides in West and North West Africa dating as far back as 2003-05 and even earlier. It also indicated that countries in Central Asia and the

Caucasus carry large stocks of obsolete pesticides that date as far back as the old Soviet era. This same report, therefore, recommends the establishment of sustainable pesticide stewardship across political borders to strengthen the PDS at national and regional levels and to reduce pesticide-related human health risks, minimize environmental pollution, increase food security and contribute to the national economy (USAID/OFDA, 2016). When PSA was initiated in Ethiopia it was with the intention of establishing an umbrella network that first organized actions at the Horn of Africa level; to proceed to a Pan-Africa level in the next phases and then to cover the Middle East and part of Asia. Setting up of a system-wide sustainable pesticide stewardship across political borders, however, requires volunteerism of national governments and technical and financial mechanisms so as to meet national regulatory requirements for the initiative to function on the ground (Paper II). The experiences from setting up the Ethiopian PSA with the motivation created at regional and local levels and the blockage because of the national regulatory requirements can be taken as lessons for future endeavors to set up similar initiatives.

The adoption of FFS by smallholder cotton farmers has been grassroots proof of practical implementation of the notion of pesticide users' stewardship by minimizing the human health and environmental impacts of pesticides and increasing yield. Moreover, PSA has been an innovation platform which has enabled the FFS to be a bridge to an institutional arrangement for knowledge co-production and transformative learning in the communities. In the collaborative learning process in FFS, the farmers became more empowered, more independent, and more capable of taking charge of their development processes (Papers III & IV). Every insect was a pest before they engaged fully in the IPM-FFS, but after the learning process they learned the presence of "farmers' friends" in their surroundings and were able to prepare "food spray" which could attract "*farmers' friends*" so as to control "*farmers' enemies*". This in turn encouraged them to give meaning to their daily lives based on interactions and communication amongst their fellow farmers, local government, researchers and federal level actors. The reaction of one of the lead farmers, who said: "*this process made us experts to explain what has been going on in our fields. We had been killing farmers' friends* […] *with synthetic pesticides considering them as pests. We can now identify farmers' friends and farmers' enemies, we even know the stages of their life cycle and which stage is important to control pests"*, indicates that they are already becoming experts of their own field through a multidisciplinary interaction and knowledge co-production that has been used by grassroots farmers as well as researchers.

Similar agro-ecological approaches in the farming systems are tested examples of mitigating pesticide- related treadmills that have been caused by agriculture modernization. Community-managed sustainable agriculture and other approaches of agroecology in Africa, Asia, Europe, North and South America have been documented as means of reducing human health and environmental hazards that are caused by highly hazardous pesticides (Watts and Williamson, 2015). However, these good practices are still not integrated into the formal extension system mainly because of the lack of political will from the national governments. With these global and national challenges, the lead farmers in the Ethiopian FFS started to think globally and critically and they convinced their members to establish an organic cotton producing cooperative to benefit from the organic premium provided by the international market. This is, according to Freire (1973), a transformation to the highest level of *"critical transitivity"*. These farmers convinced the local government to think out of the conventional way of the pest management regimen, merged critical thoughts of experts and their group with critical action in their field and showed the feasibility of IPM-FFS as one practical approach towards the notion of ethic of pesticide users' stewardship. This process also started to pay them back with a better price for their produce and brought a power shift that allowed them to be heard and to be active in their development agenda with practical action and critical reflection. These being the success factors, the farmers in the cooperatives highlight that the cotton IPM-FFS process should expand to other crops and should involve more farmers in more districts and the region as a whole so that they can have their own larger IPM/organic brand. Their future plan is to make themselves a center of excellence for sharing experiences with other farmers.

The Ethiopian experience of cotton IPM-FFS showed a reduction in the amount of pesticide use amongst smallholder farmers, which was similar to those studies in Asia (Kenmore, 1996, Untung, 1996) and other parts of Africa (Simpson and Owens, 2002). The level of farmers' empowerment, the actions of farmer-to-farmer communication and the opportunities created for women to actively participate in the FFS sessions were also similar to earlier FFS implementations in India and East and West Africa (Davis et al., 2012; Mancini et al., 2007).

As the principle of participatory action research was followed as a methodological approach, the direction of dialogue forums within PSA was not predictable. It was, therefore, kept flexible so as to lead towards institutional change through action while developing an understanding that informs the change process in addition to what was known (Dick, 2002). This resulted in the establishment of the first organic farmers' cooperative and three women's spinner associations. These four independent and decentralized institutions can be used as models of replication in other areas so as to strengthen participatory approaches.

The success of the Indonesian FFS program was related to the government's action, which was supported by a presidential decree of eliminating broad spectrum pesticides, lifting pesticide subsidies and facilitating a national IPM program (Röling and Van De Fliert, 1994) Ethiopia, however, does not have an independent IPM program to guide the extension system; but the Ministry of Agriculture does not object to the implementation of IPM at grassroots level. The challenge in front of the grassroots smallholder-driven IPM-FFS is, therefore, the support of a higher level policy decision which encourages institutional transformation (Franz, 2002; Percy, 2005, Röling and Van De Fliert, 1994), which PSA must facilitate through continued high level dialogues.

The involvement of the Ethiopian Environmental Journalists Association, which is a membership association of private and public print and electronic media, was useful. It assisted in news coverage of the PSA dialogues and its vision, trained member journalists about how to cover pesticide-related issues and prepared field-based reports on pesticide exposure risks. However, it interrupted participation because of its internal problems and PSA was not able to live up to the role that media can play in environmental communication (Cox, 2012) for better media-based high level dialogue forums.

Conclusion

This thesis dealt with the multilevel communicative, systemic, organizational and societal barriers faced during the facilitation of transformative learning around the concept of pesticide stewardship at different levels of the PDS. It tested the feasibility of a multi-stakeholder, system-wide, action-oriented, policy- directed network of key actors in addressing the pesticide problem in the Ethiopian agriculture sector. The very intention of the establishment of PSA had been to lay the foundation for pesticide users' stewardship at grassroots level. The Gamo Gofa cotton IPM-FFS smallholder farmers' situation is a localized example which can feed practical action to the regional and federal level actors so as to incorporate this experience in the national extension system.

This approach of hands-on participatory action with a flexible set of FFS sessions that encourage community-felt critical reflection by farmers would lead the transformation towards a problem-solving and farmer-centered experiential learning arena. However, as Spielman clearly indicated, this could be part of the extension innovation which had been challenged by the design and implementation of Ethiopian agriculture policies, lack of regular commitment to facilitate this innovation and the challenge of mediation between and among all actors (Spielman *et al*., 2011) to bring them to collaborate towards the pesticide users' stewardship at a national level. As demonstrated in this study, the transformation of individual smallholder farmers through engagement in collaborative IPM-FFS efforts backed up and driven by a strong sense of stewardship expressed in their own words made them witness their own ability then to transform their cooperative (organization) into organic cotton farming enterprise with potential to grow further.

The confluence of an array of enabling factors made it possible at the local level for the participants to come together as a community of peers and translate their innate sense of responsibility into viable farming practice and institutional change in a relatively short period of intervention by PSA. This offers the potential for PSA and such other novel formations to work in the reverse direction too, reciprocating, replicating and revitalizing the dialectic links between the local and the federal for a responsible management of pesticides built on an ethic of stewardship.

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Papers