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CENTRE FOR ENVIRONMENT AND DEVELOPMENT

Determinants of Adoption of Alternative Pest Management Practices in Cotton Farming: a case study from three woreda's of Arbaminch zuria, Amibara and Gewane in Ethiopia

By

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This is to certify that the thesis prepared by Tsegaye Abebe, entitled *Determinants for the Adoption of Alternative Pest Management strategies in Cotton Farming: The case of Arbaminch zuria, Amibara and Gewane districts in Ethiopia* and submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Development Studies complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

The environmental and health risks of chemical pesticide application are usually becoming a serious global risk in agricultural fields like cotton farms. In recent studies despite the existence of chemical pesticide risk on environment and health issues, the engagement of farmers for the adoption of alternative practice to chemical pesticides is still imminent in the context of cotton farms in sub-Saharan Africa including Ethiopia. However, there are few studies on examining the determinants for adoption of alternative pest management practices (APMP) for the benefits of emission reduction from chemical pesticides pollution. Therefore, an alternative pest management practices (APMP) to chemical pesticides which constitutes both agronomic and cultural Control methods (ACCM) and biological control methods (BCM) is an essential strategy in the cotton crop protection strategies and other related environmental conservation areas. This research focused with a major objective of examining factors that can influence adoption of an alternative pest management practices to chemical pesticides application activities along with farmers perception and familiarity to such practices in three cotton growing areas of Amibara, Gewane and Arbaminch zuria districts in Ethiopia. The data for study was collected from 384 farmers, using structured and semi-structured questionnaire interviews and focused group discussions. Multistage random and purposive sampling technique was employed to select the required sample size. The descriptive analysis revealed that 23 % of the sample households were adopter and 77 ***%*** *were non-adopters of these alternative strategies. A bivariate probit regression model was fitted to analyze the potential variables determining farmers' adoption and the marginal effects of different variables in the study area. Among 12 explanatory variables employed in the model, only seven variable including training on APMP, risk aversion status of chemical pesticides, risk of adoption for the alternative practices, farm size, land tenure rights, distance from nearest market, and agro ecology/division were significantly influencing the adoption of both controlling methods(ACCM and BCM). In addition the variables age and education were marginally significant to only the practices of BCM whereas extension contact and share of income from cotton farming is only significant to the practice of ACCM. The study therefore recommends that policy makers and other related stakeholders should give more attention to those influencing factor on addressing the problems since reduction of environmental pollution can generates significant economic, health and environmental benefits to cotton farmers and the society as a whole.*

Key words: Adoption, perception score, bivariate probit model, Arbaminch zuria, Amibara, Gewane districts

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Acronyms and Abbreviations

ACCM	Agronomic and Cultural Control Methods
APMP	Alternative Pest Management Practices
BCI	Better Cotton Initiative
BCM	Biological Control Methods
CMIA	Cotton made in Africa
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPI	Environmental Performance Index
EJF	Environmental Justice foundations
GTP	Growth and Transformational Plan
HHP	Highly Hazardous Pesticides
IPM	Integrated Pest Management
FAO	Food and Agriculture Organization of the United Nation
FFS	Farmer Field Schools
FGD	Focus Group Discussion
FT	Fair-Trade
GMO	Genetic Modified Organism
GOTS	Global Organic Textile Standard
ICAC	International Cotton Advisory Committee
IUCN	The International Union for Conservation of Nature

KAP	Knowledge, Attitude and Perception
LSCF	Large Scale Cotton Farms
OC	Organic Cotton
OCS	Organic Content Standard
PANUK	Pesticide Action Network United Kingdom
PAN	Pesticide Action Network
POP	Persistent Organic Pollutant
PPDB	Pesticides Properties Database
SEEP	Social, Environmental and Economic Panel
SNNR	Southern Nations and Nationality of Region
SPSS	Statistical Package for the Social Sciences
SSCF	Small Scale Cotton Farms
TBL	Triple Bottom Line
TIDI	Textile Industry Development Institute
TNC	Transnational Corporations
TRAID	Textile Recycling Aid for International Development
UK	United Kingdom
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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Chapter One: Introduction

1.1 Background of the Study

Ensuring environmental sustainability is the seventh one of the eight Millennium Development Goals (MDGs) that all 193 United Nations member states including Ethiopia have agreed to achieve by the year 2015 (UNMDG,2009). Hence, the environment is of global concern and is a very important issue for discussion for the developed as well as developing countries. It is defined as the whole physical and biological systems in which man and other organisms live.

Although it is known that pesticides enhance crop production through improved control of pests, herewith contributing to the overall regional and global economy, there is a great deal of evidence for impacts of pesticides on humans and the environment, as well as unintended side effects on non-target organisms (Aktar, 2009**).** Insecticides are responsible for a large proportion of acute and chronic health problems associated with the use of agrochemicals, representing 52% of those classified by the World Health Organization as extremely, highly or moderately hazardous (WHO, 2019). Pesticides cause an array of harms. Runoff from treated crops frequently pollute the surrounding ecosystem and beyond, with unpredictable ecological consequences. Furthermore, reductions in pest populations upset the complex balance between predator and prey species in the food chain, thereby destabilizing the ecosystem. Pesticides can also decrease biodiversity of soils and contribute to nitrogen fixation, which can lead to large declines in crop yields, posing problems for self-sufficiency from agricultural production and food security (FAO and WHO,2016).

Today global retailers and traders are looking for environmentally sustainable and competitive market in a quality wise, which is a big challenge in the current conventional cotton production through using intensive chemical pesticides unlike preferred and sustainable cotton that is produced through an alternative pest management practice (ICAC, 2018).

Cotton's most prominent environmental impacts result from the use of agrochemicals specially the pesticides where the Conventional cotton has “earned” the title of being the dirtiest crop on earth. Pesticides and insecticides used in cotton production contaminate the soil we use to grow crops, the air we breathe and the water we drink. The deaths of human and animals exposed to these contaminants are counted in the millions every year (ICAC, 2018).

Ethiopian cotton farmers often use older organophosphate, organochlorine and carbamate insecticides. Many of these qualify as HHPs, including endosulfan, Malathion, carbosulfan, dimethoate and dicofol. Endosulfan is a POP listed for global banning under the Stockholm Convention since 2011, yet it remains widely in use on Ethiopian cotton farms. Ethiopia still openly formulates and sells endosulfan. Large cotton farms may apply these hazardous insecticides up to five times each season (Nigatu, 2016).

Cotton is an important cash crop to a number of both developed and developing countries. It has a strong poverty reduction impact, because it is cultivated in small family farms in areas where opportunity for growing other crops is very limited and per capita income very low (Goreux, 2004).

The development of the cotton sector in Ethiopia is currently one of the main focuses of the Ethiopian government. Therefore, a "National Cotton Development Strategy" (NCDS) and a corresponding roadmap have been developed, addressing the time period from 2017-2032 (SOFRECO, 2017).In Ethiopia cotton sector, in order to improve utilizations of the potential of the sector, the government has formulated the Second Growth and Transformation Plan (GTP II) based on the experience we have accumulated from the first Growth and Transformation Plan (GTP I) in the five years (2010-2014). The GTP II (2015-2019) was a plan that aims at obtaining 1 billion USD from the sector export at the end of 2019 and also going to serve as a spring-board to realize the vision of the nation to put the country in the first rank in light manufacturing in Africa and also among the top ten world exporters by the end of 2025(ETIDI, 2015).

In Ethiopia, the main known cotton production systems consists of the large scale commercial farms (LSCF) and the small scale cotton farms (SSCF). In Ethiopia cotton sectors, Sixty-five percent (65%) cotton production is found in 38 high potential cotton-producing areas while the remaining 35% is in 75 medium potential districts((EIAR,2016).. In terms of cotton farming, there are two major types of farms: (1) smallholder farms that cultivate their own land on a very small scale) as well as (2) commercial farms that are owned by private companies. In terms of farming systems, there are (1) irrigated as well as (2) rain-fed cultivation systems. (EIAR, 2012).

Due to the above pesticide challenge and other ecosystem polluting farm inputs in recent years, there has been an emergence of initiatives aimed at promoting sustainability of cotton production that involve the downstream supply chain for cotton. This is evident with large retailers who have a growing interest in improving their own overall footprint and who seek to provide customers with greater confidence in the integrity of their products. As a result, there are an increasing number of production standards and systems that claim to promote the objectives of sustainable farming regarding an alternative method to chemical pesticides (Ajayi, 2016).

The Afar region cotton farms where the two district selected (Amibara and Gewane) are the areas known for their major irrigated cotton farming is practiced. Whereas the southern region of Arbaminch zuria district is well known with its rainfed agriculture except for the presence of few large commercial farms. However the major alternative pest management practices of both Cultural and Agronomic Control methods (CACM) and Biological control methods (BCM) are mainly practiced in Arbaminch zuria districts due to the probable reasons for the availability of different kinds of APMP's by enviromental affiliated organizations and the manageability of the small farm size in the Arbaminch zuria districts.

Hence, such uncertainty for the influencing factors of adoption to APMP's and over all perceptions and attitudes of farmers to enviromental sustainable pest management activities and risks of chemical pesticide applications is the motive behind this paper trying to investigate in Amibara, Gewane, and Arbaminch Zuria cotton growing districts in Ethiopia..

1.2 The Statement of the problem.

The increase in insecticide use has been driven by a surge in "secondary" pests like aphids, trips and jassids. These pests, which had previously caused relatively low levels of damage, have now become a serious threat to cotton productivity (Nigatu, 2016).

Toxic effects of pesticides in humans can occur through direct or indirect exposure. Direct or primary exposure normally occurs when one comes into direct contact with the chemicals during application, transport or storage. Indirect or secondary exposure comes from exposure through polluted environments or the ingestion of food treated with pesticides (Tadeo, 2008). The environmental impact of pesticides consists of the negative effects of pesticides on non-target species. Pesticide residues may contaminate surface waters, e.g. through runoff from treated plants and soil, or through spray drift during application (Konstantinou et al., 2006).

Studies undertaken in Ethiopia indicated that Abaya (southern Rift Valley) one of cotton producing areas in Ethiopia 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) were among the challenges to Ethiopian cotton farmers(Nigatu,2016). Furthermore "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).

Without or with minimal use of toxic chemicals, it is possible to produce environmentally friendly agricultural products, with higher yields in the longer term, without polluting and exhausting environmental resources **(**ICAC, 2018). The solution requires a holistic approach to the right for an adequate agricultural crop that includes phasing out dangerous pesticides and enforcing an effective regulatory framework grounded on a human health and environmental approach, coupled with a transition towards sustainable agricultural practices that take into account the challenges of resource scarcity and climate changes **(**WHO, 2019).

However, there are some kinds of an initiatives and organizations in Ethiopia like PAN- Ethiopia that involves in pesticides network for creation of awareness to risks of chemical pesticides. Furthermore PAN-Ethiopia started an initiative project on organic cotton production since 2013 to educate cotton farmers on safer alternatives in Arbaminch small holder's cotton growing areas. The risky use of endosulfan, and many other pesticides, by smallholder cotton farmers has also been eliminated by those farmers who have been trained on this project

Few studies have examined the determinants of farm-level non-conventional pest management practices and pesticide use in sub-Saharan Africa (Kebede et al., 1990). Yet, no empirical study has been carried out specifically regarding influencing factors with rate of adoption to APMP on cotton farms in Ethiopia (Nigatu, 2016). Furthermore, the earlier studies used univariate probit or logit model. Bivariate probit model, which has the advantage of taking into account the correlation between the disturbance and its marginal effects, is applied in this paper**.**

Hence, the level of perception and familiarity of APMP, and determinant factors for its adoption strategies in a structured and comprehensive way, is the major gaps neglected to some extents in those studies. Scientific research on pesticide practice in respect to sustainable cotton farming and alternative pest management strategy and its shortcomings in Ethiopia is lacking. These are the basic reasons why assessment of determinant and influencing factors of APMP's to cotton chemical pesticides applications with the risks of chemical pesticides applications and the associated and enabling factors to the adoption of APMP's was conducted in Afar and Arbaminch Zuria Districts of Ethiopia.

1.3 General Objective of the study

The aim of this study was to examine determinants for alternative pest management strategies to chemical pesticide applications and assess farmer's perception and familiarity to these environmentally sustainable practices in Amibara, Gewane, and Arbaminch Zuria districts/woreda's in Ethiopia.

1.3.1 Specific objectives

1. To assess the factors determining the adoption of APMP's to chemical pesticide applications in the selected districts of Arbaminch zuria, Amibara, and Gewane areas in Ethiopia.
2. To assess the knowledge, attitudes and perceptions (KAP) of farmers on alternative pest management practices (APMP) to chemical pesticides applications.
3. To identify major risks and challenges of pesticides applications to cotton farms

1.4 The Research Questions

1. What are the determining factors for adoption of alternative pest management practices (APMP) to chemical pesticides application in the selected cotton growing district's?
2. How are the knowledge, attitudes and perceptions of farmers on alterative pest management practices to chemical pesticides application practices?
3. What are the major risks and challenges of chemical pesticides application?

1.5 Significance of the Study

Environmental pollution and land contamination in cotton farms is the main factor that has a negative impact on biodiversity. The environmental pollution is currently one of the leading agendas for a number of world conservation organizations, authorities and interest groups (UNDESA, 2004**)**. According to the 2012 united nation report "Global chemicals outlook" pesticides are poisoning Africa's health service by huge $6.2 billion per year, more than the total international assistance of 4.8 billion given to sub-Saharan Africa for basic health service.

Cotton is mainly produced in developing countries: 99% of the world's cotton farmers live in such countries and produce 75% of the world's cotton (ICAC, 2018).Even though the volume of cotton produced is higher than ever, the social, ecological and economic issues occurring in cotton production are far from resolved. Of all cotton produced, about 75% is currently grown by smallholder farmers in developing countries **(**ICAC, 2018).

In 2018, the cotton sector in Ethiopia provided a livelihood for almost 500,000 households in Ethiopia (Belac prhew & Mamuye 2018).Furthermore, Ethiopia's Cotton-Textile Industry is considered as number one priority sector by the Government's Industrial Development Strategy. It is believed that the sector would play major role in the industry development strategy of the nation due to its advantages such as its labor intensiveness, ability to mobilize the masses up to the micro level, long chain characteristics of the sector which could pull many players along the value chain, linkage to the cotton agriculture for which Ethiopia has a big potential.

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. The rift valley areas of Ethiopia, which runs diagonally from the Northeast down to the Southwest that contains a distinct varieties of ecosystem which are now in the risk of pollution and land contamination from the adverse effect of chemical pesticides applications.

However, there is strong evidence in organizations like PAN-Ethiopia as there is alternative or sustainable farming practices already exist for a wide range of crops but are not yet widely adopted. PAN therefore works at all levels (such as scientific and field research, farmer exchanges, information and awareness campaigns) to promote organic, biodynamic, agro ecological, permaculture, low external input and indigenous knowledge systems.

Pest management must be seen in a broad context of crop and livestock management and sustainable farming systems which includes also nutrient cycling, regenerative technologies, soil fertility and water management.

Besides the above government strategies, the significance of this study:

- Will assist as an input for the government decision makers through providing valuable information concerning appropriate policy and legal framework to address the gaps in the existing sustainable cotton production constraints
- Can help policy makers to access additional information on the impact of sustainable cotton pest management practices and implementation strategy
- Furthermore, it can also be used as a source of information or other researchers and used as a springboard for detail studies on the impact of chemical pesticides on human health and ecosystem.

1.6 Scope and limitation of the Study

The study was confined to the three districts of Arbaminch zuria, Amibara and Gewane in southern nation and Afar region in Ethiopia. The study was limited to cotton growers in the three districts with both small- and large-scale cotton farming systems. The selected main issues in this study included farmers knowledge to the risks of pesticide use, perception and knowledge of alternative pest management practice (APMP) to chemical application and finally an assessment of determinants on the adoption decisions among cotton growing farmers. The primary survey was undertaken after 2019/20 crop harvested and during the preparation of the new crop for the 2020/21 crop year. For policies and strategies on APMP's to chemical pesticides; additional secondary information, published research papers and articles and Government reports, policy documents were referred during this period.

The findings in this study though useful were limited in that farmers interviewed hardly kept records on pesticide use and alternative practices implemented. Consequently, most of the answers to questions were based on the farmer's memory. However, thorough probing was undertaken to ensure respondents gave accurate data. Limitations in this study also linked to the unavailability of data pertaining to different types of alternative pest management practices in the study areas; specific factors affect a specific type of alternative practices practice. A further limitation is the lack of a qualitative, descriptive account of pest management practices in the area. Future studies in the area could consider these missing aspects of this study.

1.7 Organization of the Study

This thesis paper is organized into four chapters: Chapter one provides an overall introduction of the research thesis, including the background of the study and the industry, research problem, the study objectives, scope, significance of the study. Chapter two explains the literature review about the subject matter, key concepts and approaches help to establish and justify the study's theoretical and empirical basis and that would help to understanding the study. Chapter three provides details of the research methodology and methods used in this study. Chapter four explains the results of the researched topic and discusses the findings, conclusions and recommendations with guiding to further researches.

Chapter Two: Review of Literature

2.1 Theoretical Literature Review

2.1.1. General overview of cotton production

Cotton is mainly produced in developing countries: 99% of the world's cotton farmers live in such countries and produce 75% of the world's cotton. .Even though the volume of cotton produced is higher than ever, the social, ecological and economic issues occurring in cotton production are far from resolved. Of all cotton produced, about 75% is currently grown by smallholder farmers in developing countries **(**ICAC, 2018).

Cotton is one of the leading agricultural non-food commodities and ranks among the top consumers of agrochemicals. Accounting for 16% of insecticide releases among over all agricultural crops, it exceeds all other major crops in terms of insecticide application (EJF, 2007). Insecticides are responsible for a large proportion of acute and chronic health problems associated with the use of agrochemicals, representing 52% of those classified by the World Health Organization as extremely, highly or moderately hazardous (WHO, 2019).

As such, serious environmental and health risks are linked to conventional production of cotton. It is increasingly associated with problems such as soil fertility loss, water pollution and pesticide poisoning (PAN-Ethiopia, 2016). Cotton is mainly produced in developing countries: 99% of the world's cotton farmers live in such countries and produce 75% of the world's cotton (ICAC, 2018).

2.1.2. Cotton production in Ethiopia

Ethiopia possesses more than 2.6 million hectares of land suitable for growing cotton; an area that equals the cotton land in Pakistan, the world's fourth largest producer. Sixty-five percent (65%) is found in 38 high potential cotton-producing areas while the remaining 35% is in 75 medium potential districts (EIAR, 2016).

In terms of cotton farming, there are two major types of farms: (1) smallholder farms that cultivate their own land on a very small scale (see section 5.3) as well as (2) commercial farms that are owned by private companies. In terms of farming systems, there are (1) irrigated as well as (2) rain-fed cultivation systems (EIAR, 2016).

Ethiopia recently cultivates not more than 3% of the total suitable area for cotton production (ETIDI, 2018). The annual production of seed cotton was approximately 120,000 tons in the year 2011 to 2013 with an overall yield of 1.42 ton/hectare (Alebel, Firew, Berihu, & Mezgebe, 2014). Currently, majority of the cotton cultivation takes place in the Awash Valley (majority of Afar}, with some cultivation also taking place in Gambella, Humera and Metema.

In Ethiopia, the practice of an irrigated cotton production is a very common phenomenon. However out of 84,000 hectares of land that is under cotton cultivation, only 35,000 hectares is irrigated. The major potential cotton-growing areas include Omo (south and north around Arbaminch zuria), Ghibe, Wabi-Shebelle, Awash, Baro-Akobo, Blue Nile and Tekeze river basins (EIAR, 2016).
Table 2.1 below shows Cotton production, productivity, future plans, policy and strategies of Ethiopian government in the cotton sector as a whole.

Table 2.1: Ethiopian cotton Production, productivity trend and policy targets

Crop Year	Area Harvested (Ha)	Production(T) Year-to-Year Variations	Absolute (T)	%(change)
2016/17	82,000	45,000	7,000	1 8%
2017/18	60,000	38,000	7,000	-16%
2018/19	77,000	53,000	15,000	39%
2019/20	80,000	57,000	4,000	8%
Targets of Ethiopia's National Cotton Development Strategy (2017-2032)				
Cultivated Area (ha):	2017	2020	2025	**2032**
Smallholder rain fed	26,000	48,000	260,000	290,000
Smallholder irrigated	1,000	2,000	5,000	10,000
Large farms rain fed	33,000	100,000	200,000	350,000
Large farms irrigated		100,000	200,000	350,000
Total		250,000	665,000	1,000,000

Source: TIDI Report (2018).

2.1.3. Cotton Pests and Pest Management Practices

Cotton yields and fiber quality are damaged by a wide range of insect pests and diseases. Since the 1980s, insecticide use on cotton crops in different sub-Saharan African countries reduced considerably, largely due to the development of control methods based on pest monitoring. In most of the African countries, chemical control of pests depends on two methods: treatments applied according to a predetermined calendar, or insecticide applications triggered by the degree of infestation or extent of damage (CIRAD, 2012).

Numerous plant protection techniques have been tried in African countries.. In different sub-Saharan African countries, de-topping of cotton plant at the peak flowering period was introduced to reduce bollworm infestation. De-topping in China restricts plant growth, induces earliness and enables proper partitioning of photosynthates to increase yields (Dai and Dong, 2014). However, de-topping did not enhance yields, but only contributed to the reduction in bollworm damage in Mali (Renou et al., 2011). In Africa, pest management can become efficient with short-season compact-architecture varieties that are planted in high densities (Kranthi, 2016, 2018).

Because not all control options can be used against every pest, the grower has to choose the ones that are ideal for the situation. For example, systemic insecticides are more effective against pests that mine or bore into the plant tissue. Pests that follow a particular seasonal pattern can be controlled by adjusting planting dates (Renou et al., 2011). Commercially available natural enemies can be released against some, while mating disruption works well against others. Entomopathogenic nematodes can be used against certain soil pests, bacteria, and viruses against pests with chewing mouthparts such as Lepidoptera and Coleoptera, while fungi are effective against a variety of pests. In some areas, where agricultural land is in shortage or there is a continuous demand for specialty crops, certain IPM practices such as allocating space for natural enemy habitats or crop rotation are not always possible (Swezey et al., 2007).

In cotton crop protection sectors, further impacts on the environment have repeatedly been associated with the production of cotton. One of them is the use of genetically modified cotton. In most cases, a gene of the bacterium Bacillus thuringiensis is inserted. The so-called Bt-cotton is supposed to become resistant to the cotton boll worm, one of the most relevant pests for cotton (Teufel et al. n.d.). Although a short-term reduction in pesticide use can be observed, there is a renewed increase, as more problems with secondary pests occur and the cotton bollworm develops resistance over time (Tappeser et al. 2000). Furthermore, it was found that genetically modified cotton consumes at least three times more water than conventional cotton (Transfair e.V. 2009). At the same time, the use of genetically modified species always carries the risk of invasive species formation (Teufel et al. n.d.).

The Ethiopian Government has plans to increase the production of cotton over the next years, and estimates that around 3 million ha of land would be suitable (Negash & Mekuria 2018). If significant increases are implemented, conflicts concerning land use as well as land rights might arise. So far, genetically modified cotton is not used in Ethiopia, but its introduction phase it's discussed controversially on a national level. An increased competitiveness on the world market is named as main argument in favor of Bt-cotton, while the high costs for corresponding cotton seeds are seen as a major obstacle (TIDI, 2018).

This topic is especially critical, as some of the pesticides widely used in Ethiopia are not registered (prohibited) in European countries. It was reported that some pesticides which are listed Persistent Organic Pollutants (POPs) under the Stockholm convention are still used and produced in Ethiopia (Amera, 2016). Furthermore, the production of cotton in monocultures is reported to have a negative impact on biodiversity, which offer habitats only for a few species (Teufel et al. n.d.).

2.2. Conceptual Literature Review

2.2.1. The concept of sustainability and environmentally sustainable Pest management practices

The concept of "sustainability", also known as "sustainable development", was originally defined by the United Nation's World Commission on Environment and Development (1987: 41) as the capability "to meet the needs of the present without compromising the ability of future generations to meet their own needs". More specifically at the organizational level, sustainability was given the definition of "meeting the needs of its stakeholders without compromising its ability to meet their needs in the future" (Hockerts, 1999: 32). However, the interpretation of sustainable development from a corporate perspective is sometimes rather different; managers mainly associate corporate sustainability with the economic performance, neglecting the other two, and focus on the maximization of shareholder value, market share, and innovation (Bansal, 2002). Sustainability can be perceived differently depending on each organization's strategy, whether as "a compliance issue, a cost to be minimized, or an opportunity for competitive advantage" (Hubbard, 2009).

The principles to environmentally sustainable pest management practices emphasizes, rather than simply eliminating the pests we see right now, using environmentally sustainable strategies means, we'll look at environmental factors that affect the pest and its ability to thrive. Armed with this information, we can create conditions that are unfavorable for the pest (ICAC, 2018).

Environmentally sustainable approaches like the APMP or programs combine management approaches for greater effectiveness. The most effective, long-term way to manage pests is by using a combination of methods that work better together than separately (FAO & ICAC, 2015).

2.2.2. The Concepts of Alternative Pest Management practices (APMP's)

APMP is a sustainable, science-based, decision-making process that combines biological, cultural, physical, and chemical tools to identify, manage, and reduce risk from pests and pest management tools and strategies in a way that minimizes overall economic, health, and environmental risks (USDA-ARS, 2018).Several other definitions also focus on substituting or eliminating the reliance on chemical control options, adopting a number of other options with the emphasis on environmental and human health.

Alternative pest management practices to chemical pesticides consist of different kinds of pest management practices however can be grouped in the following two major categories: Cultural or Agronomic, and Biological control Methods (Ajayi, 2000)**.**

Cultural and Agronomic Controlling Methods**:** Cultural and Agronomic Methods (CACM) is an alternative pest management practice that implements the use and application of tactics such as crop rotation, intercropping, tillage approaches, cover crops or mulches, managing irrigation and drainage, removal of crop residues and other field sanitation procedures, altering planting and harvesting schedules, and related strategies (Alavalapati, Mercer and Mo, 2004).

Cultural and Agronomic Methods also includes mechanical and physical control practices that can kill a pest directly or make the environment unsuitable for it. Sticky card traps are examples of mechanical controls. This method considers the use of physical and mechanical methodology. Screening, trapping and other exclusion tactics, etc. (Alavalapati and Nair, 2001)

Biological control Methods**:** Biological control Methods (BCM) is an alternative pest management practice that apply the use of natural enemies—predators, parasites, pathogens, and competitors—to control pests and their damage. Biological can be used in the form of natural predators and parasites or as sprays to inhibit the growth of pathogens or cause death to the pest i.e. feeding deterrents, repellents, pheromone, etc.(Alavalapati and Nair (2001),and Alavalapati, Mercer and Mo,2004).

2.2.3. Concepts and Theories of Adoption Decisions for Agricultural practices

Norton (1976b) recognized four elements of a farmer's pest control decision: 1) the perception of pest hazard; 2) the range of available protection measures available; 3) the estimated cost and effectiveness of these measures; and 4) the objectives or decision rules employed by the farmer. These four elements will be used in this literature review of the perceptions or attitudes of farmers toward pest management.

Mumford, (1982) suggested, following Norton's four elements, a decision model in which choice depends on the perceptions of pest hazard and the net effect of the controls that the person is aware of and able to use. The controls selected are based on their perceived ability to satisfy the farmer's goals. Mumford also wrote that "perceptions arise from direct experience and indirect information on a subject, often filtered in the mind to produce a consistent view on a subject." Mumford (1981) found that when farmers have had direct experience with a pest problem their estimate of losses is likely to be quite good. However, the worst possible losses are rare events and may not have been experienced by a farmer. Thus, an individual may have to use an indirect means, such as farm magazines or advertisements, to estimate these losses. This type of information may not be relevant to an individual's specific situation and can contribute to the individual's lack of tolerance and need to protect the crop in all circumstances. With respect toward risk assessment, farmers are generally viewed as risk adverse in that they attempt to reduce variability as much as possible (Norton, 1982).

Two general categories of methods of pest control were identified by Norton (1976a): 1) prophylactic or pre-emptive measures which are used without an estimate of the level of pest attack, and 2) scheduled, more flexible measures which can be applied before or during pest attack. Control measures can provide two benefits for the farmer: they should reduce variance in crop revenue and they may also increase the net profit, if applied when needed (Mumford, 1981). The relative importance of reducing variance and increasing the net value can depend on the risk perception of the pest problem. A risk adverse farmer may accept a reduced net value if it were necessary to reduce variance, while a risk neutral farmer may be expected to place more value on increasing the net value.

Farmers with expectations of severe pest attack would also be expected to use prophylactic and more intensive controls, i.e., pesticides. A positive relationship between perception of pest hazard and the action taken in response was reported in Mumford (1981). Turpin and Maxwell (1976) have shown that Indiana farmers who perceive a higher level of pest damage are more likely to use pesticides than those who expect lower damage.

The lack of tolerance of growers toward pests is certainly a product of their perception of risk, but other factors also contribute. Farmers may desire not to have a "dirty" crop or to keep in line with the pest control practices of their neighbors (Norton, 1976a). The farmer's perception of the quality standards of produce imposed by processors, retailers, and consumers may also influence the decision to use a disproportionately greater amount of pesticide and to strive for "zero" pest levels (Corbet, 1981).

The implication should not be made that the use of entails a choice between pesticides and alternative controls. Pesticides are a critical component of IPM (the extent to which this is recognized by farmers is not known), but reliance on a single control should be lessened and the use of pesticides should correspond with a determined level of pests that will cause economic damage. In viewing IPM as an alternative to prophylactic pesticide treatments, it is important to determine whether farmers are aware of IPM and its component alternatives. Grieshop, et al. (1988) asked California tomato growers if they had heard of IPM, Seventy percent of the growers replied that they had; 23% answered no and 7% were not sure. The same question was asked of soybean farmers in Iowa, Indiana, Illinois, Missouri, and Ohio; only forty percent indicated that they had heard of IPM (Edwards, 1988). Similar questions about farmer awareness of biological and microbial controls were not found in the literature. There are a variety of factors that affect the decision to shift from one control strategy to another.

2.3. Empirical Literature Review

A number of studies pointed out the adoption status of sustainable pest management. For example, (Nigatu, 2016) conducted a cross-sectional pesticide Knowledge Attitude and Practice (KAP) survey among farmers in three farming systems [large-scale closed greenhouses (LSGH), large-scale open farms (LSOF), and small-scale irrigated farms (SSIF)] in rift valley areas of Ethiopia using descriptive analysis he identified majority (more than 80%) were not aware of modern alternatives for chemical pesticides, pesticide training attendance was highest in LSGH and was lowest in SSIF**.**

Several studies (Ervin and Ervin 1982; Napier 1991; Bultena and Hoiberg 1983) have been conducted to explain farmers' attitudes toward adoption of new technologies. Some researchers (Rahm and Huffman 1984; Lee and Stewart 1983; Amin 1999; Traore, Landry, and Amara, 1998) used binary choice models to measure the probability of farmers adopting soil conservation practices.

Socioeconomic factors such as education and training have been found to influence the adoption of alternative crop protection method. Khan and Damalas (2015) evaluated factors hindering adoption of non-chemical pest management practices among cotton farmers in Pakistan. Results from the binary probit regression analysis indicated that education and participation in training programs were the major predictors. This could be attributed to inadequate access to information on new agricultural technology. Economic factors such as the cost of the crop protection method and expected yields have been highlighted as drivers for adoption. Surprisingly, the perceived human and environmental effect of crop protection method was given less weight by farmers in Cote d`Ivoire (Ajayi, 2000).

Training, age, risk perception, geographical location, and income have been reported to play a role in the adoption of an alternative to pesticides. Khan (2009) used a probit model to estimate the probability of a cotton farmer to adopt eco-friendly pest control practices in Pakistan. The farmer`s likelihood of utilizing environmentally friendly pest control method was assumed to be a function of farmer and farm characteristics, plus health experience. Results from the probit regression analysis failed to support the assumption that farmers with prior ill health experience were likely to adopt an alternative to pesticide than their counterparts. Age, training, risk perception and income were found to have a positive relationship with the adoption of alternative pest management (Khan, 2009). Furthermore, the geographical location had an influence on the chances of using other crop protection methods besides chemical pesticides.

From these studies, one can conclude that most of the factors that affect the adoption of each alternative practices differ from other practice. Hence, difference in the pest management strategies of these practices, knowledge, attitudes and perceptions of farmers, and location of the farm districts can result in differences in factors affecting adoption of sustainable alternative pest management practices or strategies.

The role of risk perception, socio-economic and institutional factors in influencing the intensity of uptake of alternative pest control methods is still not clear in the empirical literature. Hence, it is on the foregoing that this study was geared towards filling these knowledge gaps among large and small-scale cotton farmers in Arbaminch, Amibara and Gewane districts of Ethiopia**.**

As noted above, different literatures written on the hazardness of pesticides or sustainable alternative pest management strategies separately with regard to pesticide risk to human health or environment.

In general, the work of the previous related studies conducted in local as well as abroad is supportive and it helps as an input for this research. However, locally in Ethiopian cotton context no specific studies have been carried out to ascertain risks of pesticide application, farmers' perception of environmentally sustainable pest management practices with influencing factors for decision to adopt or not such strategies. These are the basic reasons why determinants factors and adoption level APMP was conducted in the three districts of Afar region (Amibara and Gewane) and SNNP (Arbaminch zuria) of Ethiopia.

Hence, it is important to analyze factors affecting the adoption of alternative pest management strategies to chemical pesticides which is the main objective of this research paper.

2.4. Factors influencing the adoption of alternative pest management practices (APMP's)

Farmers with expectations of severe pest attack would also be expected to use prophylactic and more intensive controls, i.e., pesticides. A positive relationship between perception of pest hazard and the action taken in response was reported in Mumford (1981). Turpin and Maxwell (1976) have shown that Indiana farmers who perceive a higher level of pest damage are more likely to use pesticides than those who expect lower damage.

Institutional factors such as land ownership, membership in farmers' organizations, and technical assistance have been found in some studies to influence on-farm adoption of environmentally sustainable farming practices (Francis 1986). Insecurity of tenure reduces farmers' incentives to invest in land conserving practices (Lee and Stewart 1983), while membership in local groups has a positive and significant effect on the adoption of such technologies (Burton et al. 1999).

Farmer`s decision to adopt agricultural technology is influenced by the farmer`s attitude towards that technology which is in turn influenced by knowledge about the technology. Risk perception might affect farmer's practices in pesticide use. For instance, farmers whose risk perception is heightened tend to use pesticide judiciously as compared to farmers who view pesticides as unhazardous. Studies on perception, knowledge, and practices have indicated that there are cases of pesticide misuse and overuse. This can be attributed to lack of knowledge on associated health and environmental risks and wrong perception about pesticide use (Riwthong et al., 2016). This sheds light on the possible response of farmers to other crop protection technologies.

If a farmer is satisfied with the present control strategy, he/she is unlikely to be receptive to change (Norton, 1982). There is a general resistance to change (Wearing, 1988); pesticides are perceived as relatively cheap, easy to use and effective, but the farmers' perceptions of the advantages may be exaggerated. The cost of pesticides fails to account for all the deleterious social and environmental effects of their misuse. These include decreased stability and future productivity of the farming.

The lack of tolerance of growers toward pests is certainly a product of their perception of risk, but other factors also contribute. Farmers may desire not to have a "dirty" crop or to keep in line with the pest control practices of their neighbors (Norton, 1976a). The farmer's perception of the quality standards of produce imposed by processors, retailers, and consumers may also influence the decision to use a disproportionately greater amount of pesticide and to strive for "zero" pest levels (Corbet, 1981).

2.5. Conceptual Framework

The theoretical and empirical reviews of related literature mentioned above helps to develop the conceptual framework of the study. Considering the literature reviewed and the nature of the study, the following variables and conceptual frame work was selected to assess the risks of chemical pesticides, knowledge and perception of farmers for APMP adoption and determinant factors for influencing the adoption of alternative pest management strategies.

Accordingly, this study based on its objectives identifies key actors and assesses the role of APMP and the impact of chemical pesticides by using the conceptual framework depicted in figure 2.1. Accordingly, these impacts might be a key for illustrating the causes and risks of chemical pesticides, enabling factors like and level of perception, and finally the influencing factors for the adoption of an APMP's to chemical pesticides applications.

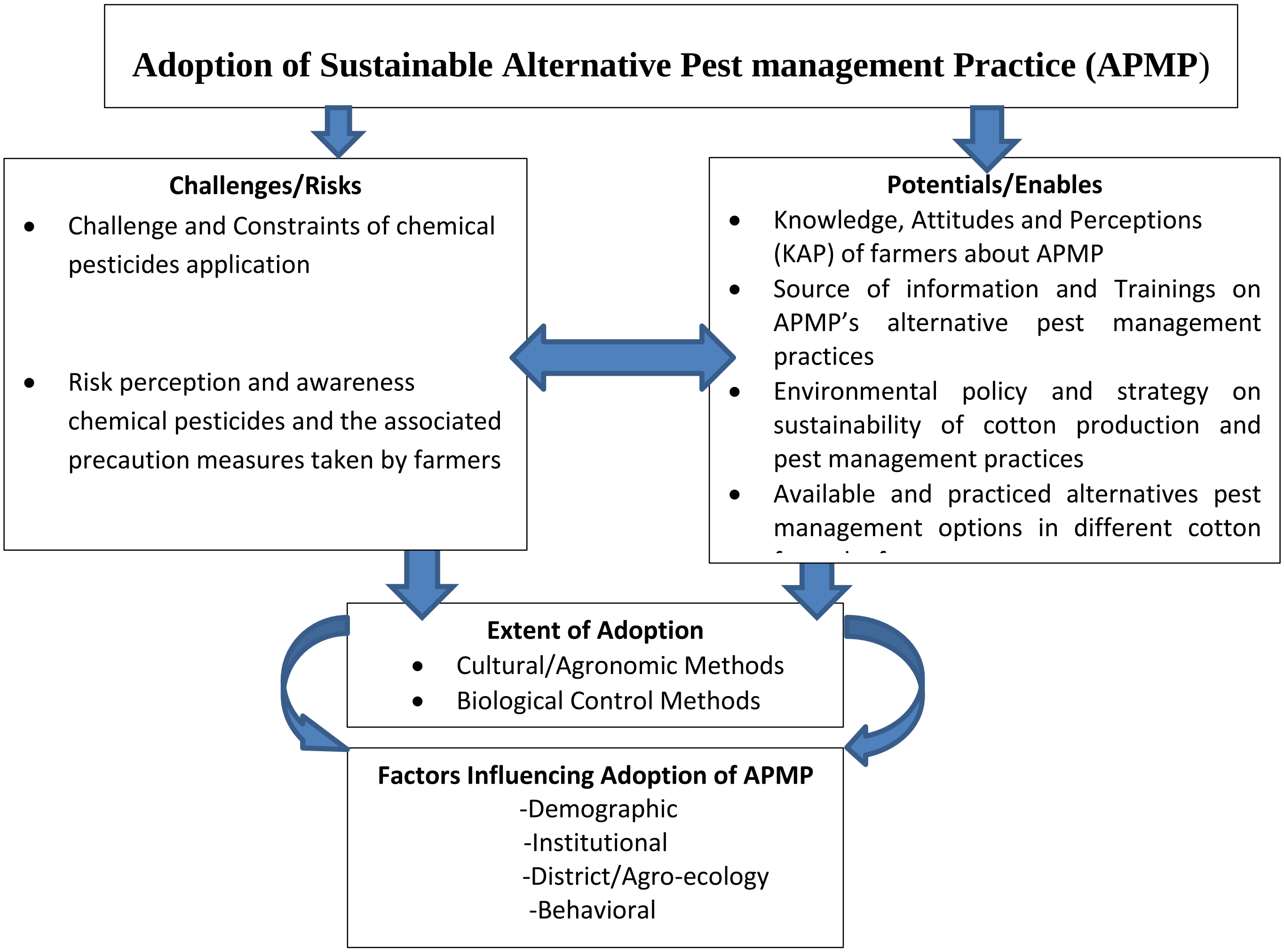


Figure 2.1: Conceptual framework of the study

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Description of the Area

The study focused on Assessments of the influencing factor for the adoption of APMP to chemical pesticide applications and examining the associated risks of chemical pesticides applications of the cotton sub sector in Ethiopia.

The study was conducted in the two locations of three districts in the rift valley areas of Ethiopia where relatively large amount of cotton production is available .The area is located near the Rift valley Lakes and Awash River (Fig.3 1.). Farms in the area can be divided in four farming systems which include LSCF, SSCF, Large scale greenhouse farm and small scale noncommercial farms. .However the latter two are not included in this study since our aim is to only commercial farms that are applying significant amount of chemical pesticides in their farming fields and closed greenhouse farm not applicable in our cotton research in the area...

3.1.1. Area description of Amibara and Gewane District (Afar Region)

The Afar area is entirely situated within the main Ethiopian rift between 90 – 120N and 390 – 410 E with its triangle form which is a world-famous geological feature formed like a funnel within the northern most part of the rift valley. The study area is situated in the southern tip (Amibara) and central part (Gewane) of this region which is found within the middle part of the awash basin. The Awash River and most of its tributaries from western part drain the Afar area being used as the existing water supply source for most part of the rural community there.

In Afar region of the two districts, the entire partial catchments is generally located in the middle Awash basin which extends from the Awash town up to Gewane area between latitude of 90,00’ (0995,850) --9052’ (1,091,201) north and 400 (0610000) –400 30’ (0665000) east. The major focus of the study i.e., the Amibara and Gewane districts is located in the eastern part of this catchment on the main Awash Assab road which lies between 240 – 310 kms (EIA, 2012)..

The climate of the Afar region in the two districts in general fall under the arid and semi-arid or semi-desert climatic zone or based on the Ethiopian Traditional way of agro-climatic zoning it can be grouped as a dry kola climatic zone with altitude ranging from 600 – 1200 m.a.s.l. with monthly temperature of 20.0c -25.0c and sparse vegetation type (EIA, 2012).

Irrigated Agriculture It is one of the most kinds of land use for some parts of the study area or zone with flat to almost flat topography (0.2%) of the region with fluvial soils type. This is an area which has potential for crop production where most part is located along Awash River.

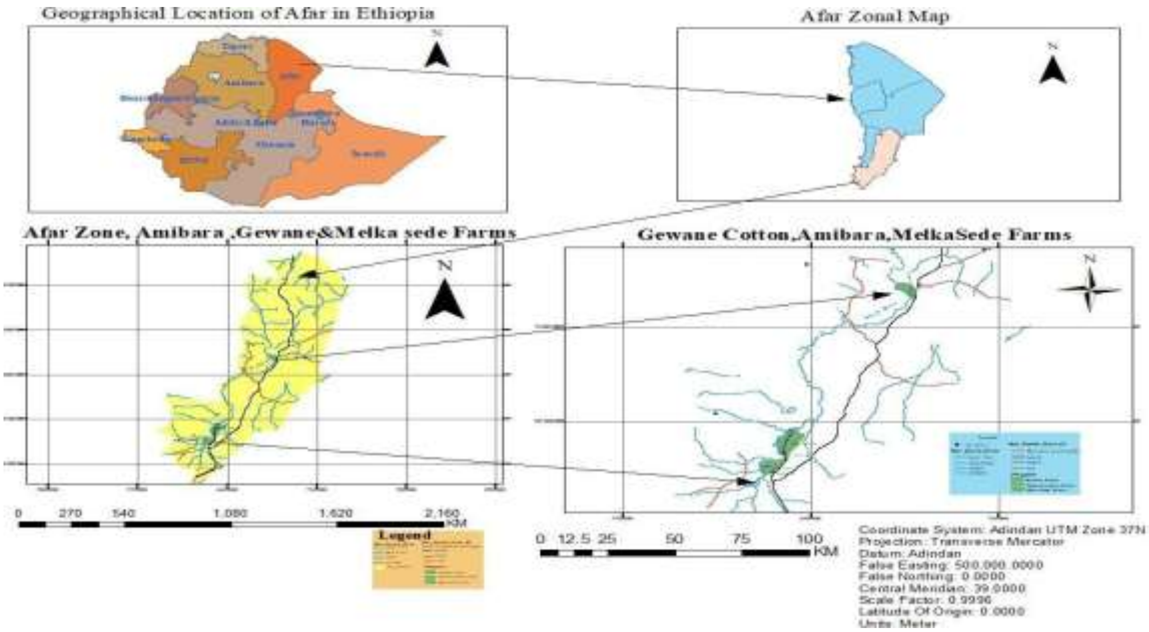
The study area of Middle Awash areas of Amibara districts dominates the cropping pattern with 87% of the irrigated land and crops like cotton, Sugarcane, banana, citrus, maize, and recently wheat farms. Amibara is one of the woreda's in zone three of the Administrative areas' of the Afar Region in Ethiopia. Amibara district is bordered on the south by Awash Fentale, on the west by the Awash River which separates it from Dulecha, on the northwest by zone five of the Administrative region, on the north by Gewane, on the east by the Somali Region, and on the southeast by Oromia Region. Towns in Amibara include Awash Arba, Awash Sheleko, Melka Sedi and Melka Werer.

Similarly Gewane district/woreda's is located in the Afar region where it's considered as one of the woreda's in the Afar Region of Ethiopia. As Part of the Administrative Zone 3, Gewane is bordered on the south by Amibara, on the west by Bure Mudaytu and Administrative Zone 5, on the north by the Administrative Zone 1, and on the east by the Somali Region; the Awash River defines parts of the boundary with Administrative Zone 5. The administrative center is Gewane; other towns in Gewane include Meteka. Gewane has an area of 967.85 square km and the administrative center is Gewane town where its nearby Meteka town which is also mainly known for its cotton production in the Gewane district (EIA, 2012).

3.1.2. Area description of Arbaminch Zuria District (Southern Region)

The study was conducted in three kebeles namely Shele Kola, Shele Mela and Chano Mile representing Arbaminch zuria woreda of Gamo Gofa Zone, in the region of the Southern Nations and Nationality (SNNE) of Ethiopia (Figure 3.1).

I. Amibara and Gewane Districts



II.Arbaminch Zuria districts

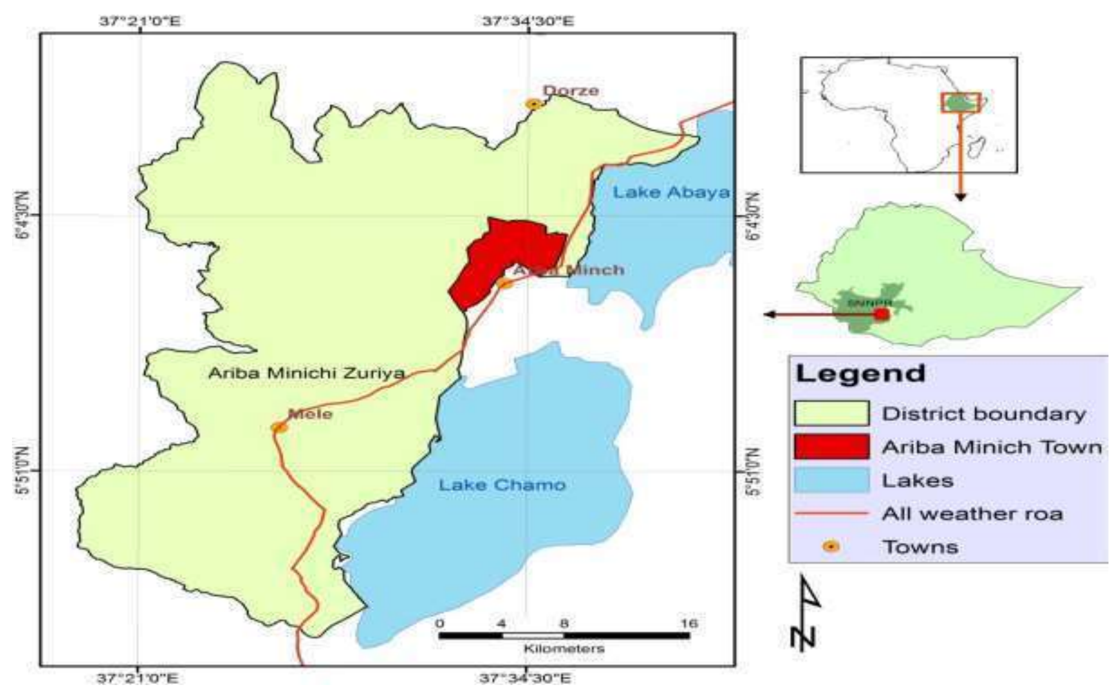


Figure 3.1: Area maps of the study area

Arba Minch Zuria is one of the woreda's in the Southern Nations, Nationalities, and Peoples' Region of Ethiopia. A part from the Gamo Gofa Zone located in the Great Rift Valley, Arba Minch Zuria is located roughly between 5°70" -6°21" N latitude and 37° 31"- 37° 67" E longitude. The woreda is found at about 500 km south of Addis Ababa, capital city of Ethiopia.

Topography of the woreda is characterized by escarpment and narrow valleys. The slope ranges between 20 and 70% which has resulted in massive soil erosion. The altitude of the woreda lies between 1150m and 3300m asl.

The drainage patterns follow the general topographic orientation, so that small rivers rising from Gamo highlands drain to Lake Abaya and Lake Chamo. Among these, Hare and Baso drain to Lake Abaya; whereas Kulfo, Sile and Sego Rivers drain to Lake Chamo (EIA, 2012).

3.2.Research Approach

In order to satisfy the objectives of this thesis research, a qualitative and Quantitative research (Mixed type) was carried out. The main characteristic of qualitative research is that it is mostly appropriate for small samples and questionnaires like semi structured and open ended once were used widely and quantitative survey like close ended questioners has been done in some of the areas or types of objectives where higher number of samples required.

A comprehensive primary survey was conducted to deduce the objective of the study including both qualitative and quantitative research methods as appropriate. The following research process was adopted:

3.3.Research design and procedures

This study can be classified under the category of descriptive research. Descriptive research is directed at determining the nature of a situation as it exists at the time of a study (Ary et al, 1990). To collect the necessary information on the current perceptions of cotton farmers in the selected districts a questionnaire format was used to survey the proposed population. In addition this method was implemented to discover the influence of chemical pesticides and adoption of sustainable alternatives pest management in the selected areas, and verify the research model. An empirical research method is then taken into consideration. The empirical research is usually done by qualitative method, quantitative method or both of them (Johnson & Onwuegbuzie, 2004). Due to the research object which is focused on the perception of farms to chemical pesticides and alternative pest management to cotton farmers in the selected three districts. The need to address or relevant data at the spot through observation and open discussions was a land at the same time to cover all vast number of respondents in the far remote areas through closed ended questionnaires, both the quantitative and qualitative method was employed in the resource collection. A face-to-face interview, FGD, structured and semi structured, open and close ended questionnaires were employed parameters simultaneously in this research thesis to fulfill the research objectives and the hypothesis in research model.

3.4. Source and Type of Data Collected

Both quantitative and qualitative data collection methods were employed using a cross sectional type of research approach in the primary and secondary information collection process. The primary data was collected through interviews by using a structured questionnaire with key informants from the supply chain actors, all the way from the producers' level up until the final consumers. The structure of the questionnaire was designed as both open and close ended questions, Details on. The close ended questions were designed as list or select any appropriate/correct answer and they were coded. The open-ended questions were designed in such a way to allowing the respondents to freely express their ideas. In addition to the questionnaires, focus group discussions were carried out with all small hold and large commercial cotton farmers in selected districts/woreda. The secondary data was acquired from published and unpublished reports of different levels of actors such as line national, zonal, district and village level agricultural extension, research, cooperative, customs and revenue, statistics, and NGO offices as well as internet (website) search-based information.

3.5. Sampling Method

The population identified for study in this investigation was made up of small-scale farmers (cotton producers) participants and Large-scale cotton farmers in the three districts of Arbaminch, Amibara and Gewane areas. A list of participants was obtained from the regional agricultural and extension offices. The population of sampling was cotton growing farmers in the three districts consisting of a total of 24 villages. Among these nine villages/ kebele's (three villages in each districts) were the target group where all the details in selecting three villages and grouping methods is shown below in table 3.1 and table 3.2.

Table 3.1: Cotton Farming villages/kebele's selected from the three districts for the study

Arbaminch Zuria District	Amibara District	Gewane District
Shele Kola	Amibara	Meteka
Shelamela	Melka Sedi	Gewane
Chano Mille	Sheleko	Unduffo

A multi-stage random and purposive sampling technique was employed to collect all the necessary primary data. Initially, three Cotton producer districts were purposively selected jointly with the respective zonal agricultural offices on the basis of their different farming types, crop production and pest management practices and volume of cotton production. Then, 9 major cotton producer farmer villages (3 villages per districts) were similarly selected purposively jointly with the respective district agricultural offices. Furthermore, the sampling technique was conducted for this study based on the experience from previous research that target respondents were easy to be found out as cotton farmers are located around the cotton growing areas. Amibara and Gewane districts from Afar region and Arbaminch zuria districts from the southern region of Ethiopia were selected since it is a quite bigger cotton farm area in the Ethiopian agro-ecology and can be considered as a representative model for both small and large commercial cotton growing regions in the country.

The study determines sample size using sample size formula **(**Kothari, 2004) for simple random sampling. To use this formula expected prevalence and confidence level is required.

$$n = [\frac{z^2 \times p \times q}{e^2}]$$

Where n= Size of sample

z= Standard variate at a given confidence level

p= Prevalence

q= 1-p (expected non-prevalence)

e= Precision

The study applies 95% confidence level which is conservative that produces the largest sample size given the other parameters constant. The study considers available resources as well as time for deciding the level of precision since there is no standard precision. The higher precision consequences the higher sample as the square precision is the denominator in the formula (C. R. Kothari, 2004).

$$n = [\frac{1.96^2 \times 0.5 \times 0.5}{0.05^2}]$$

$$n=384.$$

Assuming a 5% precision the sample size (n) is 384. Thus, 384 questionnaires are distributed to randomly selected respondent.

Finally, a total of 384 farmer respondents were randomly selected for the interview from each district, where a total list of cotton producing farmers was provided by each of the village level agriculture offices. (table 3.1)

Table 3.2: Number of respondents and grouping of samples in each district

Farmer groups	**Arbaminch Zuria District**	**Amibara District**	**Gewane District**	**Total**
Large scale Cotton Farms	18	56	52	126
Small Scale Cotton Farms	110*	72	76	258
Total number of Respondents	**128**	**128**	**128**	**384**

*Additional small farm respondents were included proportionally with a similar ratio of grouping like the previous technique.

Source: Author's own survey, 2020.

3.6. Methods and Instruments of data collection

Primary and secondary data collections were conducted by fieldwork for all empirical studies. Surveys, key informant interviews (KII), Focus groups discussions (FGD), field observations, and document analysis was applied. This mixed methods approach enables triangulation and enhances the validity and reliability of the results (Rao & Woolcock, 2003; Small, 2011). Interviews were entirely carried out. Semi-structured interviews with groups, participatory exercises (brainstorming, prioritization, and problem analysis), and open discussions in a group setting were used to identify pesticide application and pest management constraints. Selected farmers were individually interviewed using open and semi-structured interviews, combined with field observations, in order to elicit their knowledge, attitudes and practices (KAP) in pest management. KAP issues were related to the farmers' ability to identify cotton pests and natural enemies and pest management activities through their knowledge, attitudes and perceptions of the effects of pesticide use and their APMP's to chemical pesticides on cotton crops. In addition, farmers were interviewed about their individual characteristics like age, education, etc., with their objectives in producing cotton. On the average each interview took one hour.

3.6.1. Data collection Procedure

In order to guarantee the validity and reliability of the research with qualified data, different data collection methods and techniques were employed. As far as the procedure of data collection is concerned, contacts had been initially made to respondents to explain the purpose and nature of the study so as to achieve the desired response rate. Subsequently, the questionnaire was distributed to and collected physically from the potential respondents at their site by the researcher.

3.6.2. Data Collection Techniques

As it has been mentioned on the preceding part, questionnaire was employed as the instrument of data collection. The detail of the methods of data collection, sampling procedures and issues raised is explained in the following paragraphs:

i) **Survey:** Primary data were collected through semi-structured and structured surveys using open and closed questionnaires. Surveys were cotton farmers and pesticide sprayers. The surveys output also confirmed to contain all the desired response rate and useful quantitative and quantitative data. Different sampling strategies (purposive, random/probability,) has been chosen for different actor categories to claim that the data collected are representative for the category of respondents.

ii) **Key informant interviews (KII**) was conducted to obtain in-depth information from a wide range of actors (cotton Association, Environment and climate Authority PAN-Ethiopia) in addition to cotton farmers. Key informants that were interviewed included officials (experts).

iii) **Focus Group Discussion (FGD):** was conducted to obtain in-depth information from specific districts of farmers at different stages of actors in the farm community (elder farmers, farm unions, etc.).

iv) **Document analysis**: Secondary data was collected through analysis of information from relevant documents at the farm, the practiced alternative pest management activities of Arbaminch zuria districts (organic and sustainable cotton through PAN-Ethiopia). Grey and official literature and documents on the past and current state of pesticide registration (dossier evaluation), import and distribution, proclamations and conventions were also reviewed. A different theoretical framework was applied to analyze the data. Thus, qualitative information was analyzed based on theoretical frameworks, while the quantitative parts are analyzed through descriptive statistics and inferential analysi**s**.

Multi-item scales that were meant to capture factors/dimensions of the theoretical constructs, namely environmental sustainability status like strategies and policies, Environmental risks of chemical pesticides, and integrated pest Managements was implemented. The items were measured on five-point Likert scales that range from strongly disagree to strongly agree and also some additional qualitative questions related to the study objective and questions. Respondents were requested to allocate/select scores for each of the items on the instrument by taking their knowledge and actual situation in mind.

The first section of the instrument asked respondents to provide demographic information about the farm household. The second part asked about crops grown on the farm and their significance. Additionally, this section also contains question to be asked about pesticide use on their farm. The third part asked about farmers pest management practices specially the alternative pest management practices and their decision criteria to apply such crop protection strategies. These questions included whether the farmer uses pesticides, whether they were organic or nonorganic, and application methods. The participant's perceived risk of exposure was measured on a scale from 1 to 5 to their level of agreement for the selected statements, with 1 being strongly disagree, and 5 representing strongly agree to the risks of chemical pesticides to the environment and their health issues.

In perception section of the survey instrument contained 15 perception statements using a five-point Likert scale to APMP. The descriptors of the scale were as follows: 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree. The scale is a continuum: "neutral" was considered a response of uncertainty of whether respondents agreed or disagreed with each perception statement. The analysis was drawn after calculating the perception score. Based on the perception score, the farmers were divided into three categories. The numbers of respondents who gain score up to 35, their perception level was treated as low; lies between 36 to 55 were medium and above 55 were considered as high (Oyewole,2015). Though farmers' perception level was treated as a continuous variable but for an interpretation purpose the researcher made three categories by dividing three equal distances of the ranges (15 to 75) as: lower, medium and higher perception to farmers' level of perception towards adopting alternative pest management practices.

In the attitudes section, questions were also included about which APM practices the farmer was familiar with, if the participant was familiar with beneficial insects, and which practices were used. Finally, participants were asked about their interest in future alternative pest management practices to chemical pesticides and pesticide safety trainings.

In the adoption section for determining the level of adoption, questions were asked based on different kinds of alternative pest management practices as how frequently they practices the three types(cultural/agronomic, physical/mechanical and biological control methods) of practices or strategies. As the main objective of this study was to identify the influencing factors for adoption of APMP, there was a need to measure the extent to which practices related to APMP to chemical pesticides were adopted among farmers in the three districts of Arbaminch, Amibara and Gewane areas. In order to achieve this goal, 10 agricultural practices were studied. These practices were surveyed in association with farmer's level of adoption through Likert scale questions with the 10 selected APMP or strategies. The survey as illustrated in the annex III, the level of adoption of each practice expressed by the respondents using a scale from 1 to 99.

Hence, farmer's perception to the level/extent of APMP adoption is measured as: *1=Never,2=Seldom,3=Frequently, 4=very frequently, 5=Always,* where the questions include "How often you rotate", and other alternative management practices. Each participant was surveyed on an individual basis. Participants were asked to provide consent to participate. Each survey took approximately from 45 minute to 1 hr. to administer.

3.7. Method of Data Analysis and Presentations

3.7.1. Data Presentation Methods

The results findings were presented in tables. Frequency tables and percentages was used to summarize the demographic information of respondents; whereas, descriptive statistics such as Mean, Standard deviation, reliability analysis and regression of the respondents' scores on all the dimensions was assessed in order to determine the influencing factors determining the adoption of APMP to chemical pesticides application with the farmers and the related stake holders. Finally, detail interpretation and discussion of the results of the statistical and inferential analysis was implemented for the study.

3.7.2. Methods of Data Analysis

Once the data are collected, coded and edited, the analysis was done with the support of Stata.14 software version. Descriptive statistics like frequency, mean, and standard deviation was used to analyze quantitative personal and socio- economic characteristics of the respondents. Furthermore, inferential statistics like Chi-square and T-test was used to evaluate whether there are significant relationships between different dummy/categorical and continuous variables respectively. A level of significance of .05 was set a priori for all inferential statistical procedures with the implementation of a bivariate probit regression model. On the other hand, the qualitative data was analyzed through narrations and descriptions.

Perception score was used to analyze the extent of perception and adoption level. To analyze the determinants of the adoption of APMP the Bivariate Probit Model was adopted since the dependent variable is dichotomous while the independent variables are the combination of both dichotomous and continuous variables. Thus, The Bivariate Probit Model helps the prediction of probability that a farmer does adopt or not adopt a technology with its marginal effects based on given variables.

3.8. Conceptual framework and analytical considerations

The conceptual framework for the analysis is based on partial adoption of agricultural innovation (Feder etal,1985).Adoption of agricultural innovation was hypothesized to be a result of an elaborate a setoff inter-technology choice made by a farmer's household head among available alternative production inputs. The factors influencing adoption of APMP can be estimated using Logit, Probit or Tobit models (Ullah and Shivakoti, 2014). A bivariate probit model is developed to examine the relationship between different influencing factors including individual, socio-economic, behavioral and institutional characteristics and the use of each alternative pest management practices with its marginal effects. Adoption behavior is affected by the acquisition of information (Rodolfo and Nayga, 1996). Previous studies in sub-Saharan Africa suggest that information acquisition, and consequently adoption behavior, is influenced by various individual characteristics (Hailu, 1990; Adesina, 1996; Nkamleu et al., 1998).

3.8.1. Conceptual model: the bivariate probit model and Estimation procedures

Several empirical studies have tried to capture the influence of socio-economic and institutional variables on farmers' adoption decision. In most cases, the use of probit or logit model is applied (Rahm and Human, 1984; Hailu, 1990; Kebede et al., 1990; Adesina, 1996). In these models, farmers are assumed to make adoption decisions based upon an objective of utility maximization. We used the Agronomy and Cultural methods (CACM) of the alternative practices as a binary variable and as the dependent variables in our model (1 if farmers adopt CACM as an alternative pest management practices, and 0 otherwise). In our model, a biological control method (BCM) is also used as the dependent variables. We used biological control methods (BCM) as a binary variable in our model (1 if a farmer adopts BCM as an alternative pest management practices, and 0 otherwise). The underlying utility function which ranks the preference of the ith farmer is assumed to be function of farmer-specific attributes, ``X '' (e.g. age, education, farm size, etc.) and a disturbance term having a zero mean.

Bivariate probit approach**:** The impacts of various factors on the adoption of the two types of alternative management practices (CACM and BCM), are assessed using a bivariate probit model. The bivariate probit model is described below:

$Y_{ij}=X_{ij}\ \beta_j+\varepsilon_{ij}$……………………………………………………………………………………(2)

Where, Y_{ij} (j=1,… m) represents alternative pest management adoption options.

Here, m=2, i.e., APMP's adopted by the ith farmer (i=1, ..., n), X_{ij} is a 1×k vector of the observed variable that affects the decision of risk management strategies, β_j is a k×1 vector of unobserved parameters which are to be estimated and εij is unknown error term. In this condition, each Yj is a binary variable, and thus eq. (2) is a system of m equations (m=2) to be estimated (Ullah and Shivakoti 2014):

$Y_1* =\alpha_1+X\beta_1+\varepsilon_1$

$Y_2* =\alpha_2+X\beta_2+\varepsilon_2$ ……………………………………………………………………… (3)

Where Y_1 * and Y_2 * are two latent variables underlying each of the alternative pest management decision such that Yj=1 if $Y*j$>0; otherwise 0. The conditional marginal effects of the bivariate probit model have also been figured out. The explanation of the marginal effects then refers to a reference variable.

Where the marginal effect of an explanatory variable illuminates that what fraction will change the probability that reference variable is taking part in dependent variables if a value of that explanatory variable is augmented by one unit (Adnan *et al*. 2018).

3.8.2. Empirical model

The empirical specification of the adoption model is employed to investigate the adoption decision of alternative pest management practices (APMP) for the practices of agronomic or cultural methods(CACM) and biological control methods (BCM). A bivariate probit model is developed to examine the relationship between different factors including individual, socio-economic, behavioral and institutional characteristics and the use of each alternative pest management practices. Adoption behavior is affected by the acquisition of information (Rodolfo and Nayga, 1996). Previous studies in sub-Saharan Africa suggest that information acquisition, and consequently adoption behavior, is influenced by various individual characteristics (Hailu, 1990; Adesina, 1996; Nkamleu et al., 1998).

The farmers' twelve characteristics were treated as independent variables or predictors in the study. Some of these are binary/dummy while others are continuous. The dependent variable adoption of APMP is binary and dummy in nature. The type and measuring techniques of both independent and dependent variable are presented in Table 3.3. As the dependent variable may have any one option of the two; either the adoption or rejection of each types of alternative practices (agronomy/cultural and biological methods).Hence, to justify the impact of independent variables on APMP's adoption, and estimate the probability of adoption for the specific practices with their marginal effects, bivariate probit regression model is considered the most appropriate (Hailu, 1990; Adesina, 1996; Nkamleu et al., 1998).

The variable characteristics and descriptions of the variables included in the empirical model are given in Table 3.3. The dependent variable is whether or not the farmer used agronomic (cultural) control methods and/ or biological control methods. For, agronomic (cultural) control methods this variable is given by CACM, and for biological control methods, the variable is BCM which take on the value of 1 if the farmer is currently using the practice and 0 otherwise. The farmers 'specifically considered explanatory variables are the farmer AGE, FAMEXPRCE ,FARMSZE , LANDTNR, EDUCTNLEVL, EXTSNCONTCT, TRNGONAPMP, MEMEBRSHPS, DISMARKET, DSTRCT, CHMCLRSK, and ADPTNRISK.

Table 3.3. Summary table for the list of factors influencing APMP Adoption

S.No.	Variables	Descriptions of variables	Measurement scale	Expected Signs	Identified Sources
1	AGE	Age of head of the household (years)	Continuous	+/-	Damalas and Hashmi, (2010)
2	FAMEXPRCE	Number of years working in the farm(years)	Continuous	+	Damalas (2010)
3	FARMSZE	Farmer's land size (in hectare)	Continuous	-	Gupta (2016)
4	LANDTNR	Land tenure status, Dummy ,=1 if they own land,&=0 otherwise	Dummy (categorical)	+	Nigatu (2016)
5	EDUCTNLEVL	Level of Education Dummy, = 1 if farmer is above primary education = 0 otherwise.	Dummy (categorical)	+	Riwthong et al.(2016)
6	EXTSNCONTCT	Number of extension contact per season	Continuous	+	Karunamoorthi et al., (2012)
7	TRNGONAPMP	Status of trainings on APMP, ,& Dummy where,=1 if they got training on APMP, & =0 otherwise	Dummy (Categorical)	+	Karunamoorthi et al., (2012)
8	MEMEBRSHPS	Access to organizational memberships, dummy,=1, if they are ,&=0 otherwise	Dummy (Categorical)	+	Damalas , (2010)
9	DISMARKET	The nearest market distance to their farms(in km)	Continuous	-	Feleke, S. and Zegeye, T, (2005)
10	DISTRT/Regional Location	Their Location among the two regions, Dummy, where,=1, if in Afar,&=0, otherwise	Dummy (Categorical)	+/-	Riwthong et al., 2016),
11	CHMCLRSK(Risk perceptions of chemical pesticides)	Risks from chemical pesticides, Dummy, where=1,if thy take precautionary measures, &=0 otherwise	Dummy (Categorical)	+	Wang et al., 2017).
12	ADPTNRISK (Attitudes for Adoption)	Farmers familiarity to APMP,=1, if they are familiar &=0 ,otherwise	Categorical	+	Wang et al., 2017).

3.7.3. Variables used in the analysis

A number of working hypothesis were employed and literatures were consulted in constructing the model since there is no firm econometric theory that dictates the choice of independent variables in adoption studies. The factors influencing the adoption of APMP were roughly categorized in to four: farmer characters, Institutional factors, biophysical/agro-ecological, and behavioral factors.

The farmer characters: The farmer characters includes, age, farm experience, educational level, and share of income from cotton operation. Where,

Age of farmers': The *age of farmers'* is a continuous variable that can be measured in the number of years. As the age of the household head increases, the probability to adopt an APMP decreases. On the other hand, when household is getting older, farmer respondents' could have experiences and assets to utilize previous practices. Hence, Age of farmers' is either positively or negatively influences the adoption of APMP (Damalas and Hashmi, 2010).

Education level of the farmer: it is a dummy variable that takes the value of 1 if the respondent farmer is literate (above primary level) and 0 otherwise. It is clear that as the level of education increases the farmers' exposure to new ideas and information increased and hence, enables the household head to adopt alternative pest management practices. Education is expected to influence APMP adoption positively (Riwthong et al., 2016).

Institutional factors :The second set of explanatory of APM adoption comprises all about Institutional factors that includes, farm size, Land ownership status, access to credit, source of information, training on APMP, and finally farmers group membership where,

Farm size in ha**:** It represents the total farm land size in ha. Farmland size is a continuous variable that can be measured in hectare. This variable is continuous and accounts for the farmer's total plot size used for farming. Studies have shown that farm size influence on Conservation Agriculture adoption can be positive, negative, or neutral (Knowler & Bradshaw, 2007). In Lesotho, Malawi, and South Africa, for instance, it was found that farm size has a direct effect in environmentally sustainable farming practices adoption decision making (Bisangwa, 2013; Chisenga, 2015; Ntshangase et al., 2018). Table 4.1 indicates there are statistical differences in farm sizes between adopters and non-adopters. As such, this study added farm size in a regression framework to see if this is causation or correlation.

Extension Contact*:* it is it is a continuous variable that can be measured with the number of vast made through extension agents... It is clear that as the level of a household farmer contact with development agents within a crop calendar. The more times of extension workers visits is expected to positively influence farmer's adoption decision. Source of information have been found to influence farmers knowledge as well as the adoption of agricultural technology Moreover, information sources (social learning, extension officer, and pesticide sellers) played a role in the adoption of health protection practices in Bangladesh (Alam and Wolff, 2016).

Farmers who have contact with extension agents tend to have better access to information on new technologies. Access to extension or research agents can also substitute for lower levels of education if they assist farmers in dealing with some of the managerial complexities of chemical pesticides. It is hypothesized that extension contact is positively related to the adoption of chemical input (Karunamoorthi et al., 2012).

Training on APMP: Training is a dummy variable. This variable takes the value 1 for farmers trained in APMP and 0 for untrained farmers. The lack of proper environmentally friendly pest management/crop protection knowledge is reported among the barriers to sustainable agricultural practices adoption (Giller et al., 2009; Kassam et al., 2009; Derpsch, 2007; Friedrich et al., 2010). It is expected that for those APMP trained farmers, there will be a higher probability of APMP adoption.

TENUR indexes the land tenure rights**.** It takes the value of 1 if the farmer has permanent tenurial rights and 0 otherwise. Permanent land rights can be from direct land purchase or divided inheritance. Farmers with permanent land rights often take into account the negative long-term effect of chemical input use. Also, due to the fact that permanent rights enable the use of soil regeneration and pest control alternatives such as the planting of trees, it is less likely that chemical inputs will be used on permanent land rights compared to temporary land rights (Nigatu, 2016).

District level/ biophysical or agro-ecological factors :The third set of explanatory variables for APM adoption comprises the district level/ biophysical or agro-ecological factors that includes, distance of the farm from the nearest market (DISMARKET) and agro ecology (division) where,

Market distance: it is the distance between household home and the nearest local market and measured in km. (Feleke, S. and Zegeye, T, 2005) noted the negative and significant association of market distance with the adoption of new farm practices like improved maize. This indicates that a farmer living at a distance from market centers is less likely to adopt APMP than those who are located closer. Thus, it is expected that the closer the local market is the higher the probability of APMP adoption.

District/Agroecology/Arid &semi-arid: Arid& Semi-arid is a dummy variable used to test for location (agro-ecological zone) impact of APMP adoption in the two regions (Afar &Sothern/Arbaminch region) of Ethiopia. This variable takes the value 1 for Afar region/territory, meaning the farm is located in the arid &semi-arid agro-ecological zone, and 0 for Arbaminch zuria territory, meaning the farm is located in the humid and moist lowland agro-ecological zone.

Based on agro-ecological studies, (Riwthong et al., 2016), recommends a regional approach in promoting farming technologies such as sustainable /conservation agricultural practices because they are “location-specific” and address “niche-type constraints faced by farmers” (p.1327). Agro ecological information types are linked to crop growth, development, and yield/loss, and so would impact the spread of conservation agriculture say Sithole, Magwaza, and Mafongoya (2016), who observed conservation agriculture impact on maize yield in South Africa.

Behavioral factors: The final set of categories includes behavioral factors including risk perception of chemical pesticides (risk averseness behavior of farmers) and risks of adoption for APMP *where,*

Chemical pesticides Risk perception*:* Risk perception of chemical pesticides has been reported as determinants of safe pesticide use. Preceding studies have found out that farmers who perceive pesticide as harmful or have previously experienced pesticide-related illness tend to apply precautionary measures (for wearing PPE) while using pesticides, unlike farmers whose pesticide risk perception is low (Ríos-gonzález et al., 2013; Damalas and Abdollahzadeh, 2016).

It is expected that a farmer who took a better precautionary measure (for wearing PPE) increases the probability of adopting APMP.

Attitude towards Risk of Adoption: Farmer`s decision to adopt agricultural technology is influenced by the farmer`s attitude towards that technology which is in turn influenced by knowledge about the technology. Risk perception might affect farmer's practices in pesticide use. For instance, farmers whose risk perception is heightened tend to use pesticide judiciously as compared to farmers who view pesticides as unhazardous. This can be attributed to lack of knowledge on associated health and environmental risks and wrong perception about pesticide use (Riwthong et al., 2016). This sheds light on the possible response of farmers to other crop protection technologies.

3.8. Reliability and validity of the study

In order to guarantee the validity and reliability of the research with qualified data, different data collection methods and techniques were employed. Before analyzing the data, reliability of the survey was tested. Reliability was defined as the degree of consistency with which an instrument measures whatever it is measuring **(**Ary, Jacob, 1985). According to (Sax, G, 1974), one of the empirical procedures to estimate reliability is based in the correlation among the items on a single test.

This correlation coefficient has been called a measure of internal consistency (homogeneity). In this research, internal consistency was calculated using the Cronbach alpha composite coefficient. Alpha coefficients were computed for the 10 items related to farmers' adoption of alternative practices and for the 45 items related to perceptions and attitudes toward the APMP, yielding values of 0.81 and 0.89, respectively. Both coefficients indicated that the consistency of the survey was acceptable. According to (Nunnally, J.C, 1982)**,** an alpha greater than 0.65 is the minimum recommended for research purposes. ARY, Jacob, (1985) concluded that the degree of reliability needed in a measure depends to a great extent on the use that is to be made of the results. If the measurement results are to be used for making a decision about a group or even for a research purpose, a lower reliability coefficient (in the range of 0.30 to 0.50) might be acceptable.

CHAPTER FOUR: RESULTS AND DISCUSION

4.1 .Descriptive analysis

4.1.1. Demographic structure in the study area

The researcher distributed 384 questionnaires to gather the required data whereas only 262 questionnaires were fully filled out and returned which makes the return rate 68.05%.

Table 4.1. (a) Mean differences of continuous and discreet variables for adopters and non-adopters of APMP.

I.Continous Variables

S. No.	Variable	Whole Sample N=262(100%)	Adopter N=59 (22.5%)	Non-adopter N=203 (77.5%)	Significance
		Mean (st.dev.)	Mean (st.dev.)	Mean (st.dev.)	
1	AGE	37(7.302)	34.34 (9.48)	41.34(10.92)	1.821**
2	FMSIZE	36.18(6.582)	9.55 (5.07)	86.22(22.04)	-1.432 **
3	FARMEXP	36.18(6.582)	9.64 (3.43)	16.22 (5.11)	0.121
4	YIELD	2016.95(769.03)	15.12(6.87)	24.1 (7.5)	-1.158**
5	DISMARKET	22.03(29.04)	6.7 (3.51)	25.01 (36.85)	-1.889***

II. Discrete Variables

No. Variables	Total Farm Frequency (%)	Adopter Frequency (%)	Non-adopter Frequency (%)	Significance
6.LNDOWNERSHP				
Owned	***210(80.1)***	***47 (91.9)***	***192(74.95)***	***0.532***
Rent	***52(19.9)***	**12(8.07)**	**11 (25.05)**	
7 EDLVL				
Literate>6th grade	**218(83.2)**	**54 (91.53)**	**164 (80.79)**	**1.829****
Illiterate < 6th grade	**44 (16.8)**	**5 (8.47)**	**39(19.21)**	
8 APMPTRAINGS				
Took training	**149 (56.8)**	**38 (66.4)**	**48(23.64)**	**16.75*****
No trainings	**113 (43.2)**	**21(33.6)**	**155(76.36)**	
9.Region				
Afar	***72(27.3)***	**21(35.77)**	**155(76.35)**	**1.961*****
Not Afar	**190(72.7)**	**38(64.23)**	**48(23.65)**	
10. CHEMCAPRSK				
Took Precaution	**85 (32.3)**	**47(78.66)**	**54(26.89)**	**0.084****
No precaution	**177 (67.7)**	**12(20.34)**	**149(73.11)**	
11.ADOPTIONRISK				
Who are familiar	**61(23)**	**54(91.11)**	**90 (44.55)**	**43.211*****
Not familiar	**201 (77)**	**5(8.89)**	**113(55.45)**	

****, **, and * represent level of significant at 1%, 5%, and 10% level respectively. Numbers in parentheses indicate percentages.*

Source: Own survey result (2020).

Table 4.1(b): Main Demographic Characteristics of farmers' with farming types and districts' level

		Region/Districts			Farm Type				All Farms	
		Arbmnch (n=78)	Amibra (n=94)	Gewne (n=90)	Large Fam (n=71)		Small Farm (n=191)		Total (N=262)	
a		%	%	%	N	%	N	%	N	%
Age of Respondents	<30	5	2	1	1	1.4	6	3.1	7	2.7
	30-40	47	62	67	50	70.4	106	55.5	156	59.5
	>40	48	36	32	20	28.2	79	41.4	99	37.8
		.			Mean 36.18 Stdv. 6.582		Mean 38.06 Stdv. 8.169		Mean=3712 Stdv.=7.302	
Educational Background of Respondents	No formal education/primary	36	12	6	5	7.1	39	20.4	44	16.8
	Secondary junior/7-8	16	51	39	28	39.4	67	35.1	95	36.3
	Secondary senior/9-12	29	26	43	25	35.2	62	32.5	87	33.2
	College+	19	11	12	13	18.3	23	12.0	36	13.7
Farming Experience of Respondents	>10	31	44	41	37	52.1		234.0	102	38.9
	<10	69	56	59	34	47.9		66.0	160	61.1
					Mean=. 10.75 Stdv.= 7.460		Mean=12.69 Stdv=. 7.268		Mean=. 36.18 Stdv=. 6.582	
Size of farm area owned by Respondents	<5ha	13	0	0	0	0	16	8.3	10	3.8
	5-15ha	68	34	19	0	0	96	50.3	100	38.2
	16-50ha	0	35	50	0	0	79	41.4	80	30.5
	>50ha	19	31	31	71	100	0	0	72	27.5
					Mean =141.8 Stdv=. 100.59		Mean= 12.25 Stdv =.31.67		Mean= 36.18 Stdv=. 6.582	
Risk of chemical pestiside	Yes, who are familiar to APMP	47	25	15	28			21		23
	No, Not familiar with	53	75	85	72			79		77

Source: Own survey result (2020).

The results of the study in table 4.1 shows that 59 (22.5%) of the sampled farmers were found to be adopters, whereas the remaining 203 (77.5%) were non-adopters.

Table 4.1. Indicates that the surveyed farmers had an average age of the over all farmers is 37 whereas, for adopters and non-adopters it was 34 and 41 years respectively. This implies, younger farmers are more interested to adopt APMP compared to older farmers. Results of this present study reveal that the younger groups had good participation in the adoption of APMP. The education level of the farmer is expected to have a positive impact on decision making.

Regarding the discrete variables in table 4.1 also indicates that the interviewed farmers in both groups had acquired a basic education (at least primary education) for all farmers group was 83.2 %, while for adopters and non-adopters, it was of 91.53% and 80.79% respectively.

Furthermore, risk of adoption is also significant like the training and risk averseness of farmers on chemical pesticides applications. A risk of farmers on positive attitudes or familiarity towards adoption of APMP's for the whole farmers was 23 %. Regarding adopters and non-adopters it was indicated as 91.11% and 44.55% of favorableness towards adoption of APMP respectively. This result is supported by (Nigatu, 2016), indicating more than 75% were non adopter of alternative pest management practices or in other words like this result he explained less than 25% of farmers are adopters of APMP's.The result also shows majority of Arbaminch zuria farmers were more practitioners of APMP which was also supported by the researcher Nigatu (2016) farmers who practices either CACM or BCM practices are adopters of APMP either by default or intentionally.

Four continuous and five discrete variables for the different alternative pest management practices were found significant with 1% and 5% probability level. According their t-value and chi-square test value, age, farm size, education level, cotton yield, and risk averseness of chemical pesticides are reported to be highly significant ($P<0.05$).

4.2. Farmers' Knowledge and perceptions of risks and challenges on the usage of chemical pesticides

4.2.1. Major challenges and risks of pesticides applications to cotton growing farmers

Selected Respondents with KII with 30 farmers (10 from each districts) and three focus FGD of 18 farmers from all the three districts (six farmers in each districts) were also asked to list or explain their constraints and challenges on the barriers of adopting alternative practices with an open-ended questionaries' and the following opinions were reflected:

One respondent of LSCF from Arbaminch Zuria districts of kebeles (Tadiwos Bontu,40 years),expresses the highlights of their and nearby cotton farm challenges for not adopting APMP as follows:

> "even *though we believe the advantage and of health and environmental risk in addition to less cost to chemical pesticides, it's a big challenge in a bigger farm like ours, since it needs intense management and availability of all-natural materials/bio pesticides in specific area like here in Arbaminch*"

He also added that in his neighboring small farms who perform well with PAN-Ethiopia NGO always observing the available opportunity he can learn from their daily practices. Here policy implication must be stressed on intensification of such sustainable practice that is welcomed by many farmers in the area.

Another group of farmers in the FGD from Gewane district of undufo kebele/village, which is remote to nearby town unlike other two districts were requested to explain their challenges to APMP adoption. Here also they were complaining double challenge in the following opinion:

> *"We are not trained or educated for both type crop protection what you are mentioning neither the chemical nor the alternatives to chemical application. We need training to rescue ourselves from chemical pesticides and also need knowledge alternative techniques either to have safer health and environment or reduce our cost of chemical pesticides*"

In the above mentioned Focus Group Discussion (FGD) and Key Informant Interview (KII) results showed, as there needs to be an intervention of capacity building, avail information source and trainings to farmers from all stake holders including governmental and NGO's.

Past studies also indicated that, farmers with expectations of severe pest attack would also be expected to use prophylactic and more intensive controls, i.e., pesticides (Turpin and Maxwell, 1976). A positive relationship between perception of pest hazard and the action taken in response was reported in Mumford (1981). Turpin and Maxwell (1976) also have shown that Indiana farmers who perceive a higher level of pest damage are more likely to use pesticides than those who expect lower damage.

According to the sample surveyed in the three districts (table 4.2.), there is a difference in the magnitude of the challenge among of the three different farms. There has been growing concern in the general public in Ethiopia about the adverse effects of pesticide on human health and the environment. Therefore, in this study, farmers were asked about their experience of any health problems from pesticides**.** A lesser percentage (6%) of the farmers in Arbaminch zuria districts have experienced illnesses probably because of the low level of pesticide use.

Table 4.2. The major challenges and risks of pesticides applications in overall cotton farms in Percentage's (%) and Frequency's (f)

No	Challenge/Constraints	Arbaminch District n=78			Amibara District n=94			Gewane District n=90		
			%	f		%	f		%	f
1	Land contamination		52	41		11	11		10	9
2	High cost of chemicals		9	8		35	33		25	23
3	Poor variety for less chemical pesticides		11	9		12	12		8	8
4	Lesser knowledge for chemical free production		5	4		8	8		34	31
5	Human health risk		3	3		7	7		11	10
6	Shortage of pesticides		2	2		18	17		16	15
7	Lack of space for disposal		14	11		6	6		4	4
8	Enforcement of regulatory measures (available occupational and environmental proclamations)		10	8		3	3		2	2

Source: Author's own compilation, 2020.

We observed land contamination is a major challenge (52%) and the highest one to Arbaminch farmers. This specific argument was also cross checked and triangulated with focus group discussion and KII**.** Some of the respondents key concern in Arbaminch farm includes the small size of their farm and population pressure in the area that make land contamination very high unlike Afar cotton farms where less population pressure and bigger farm lands found abundantly.

This finding is supported by (Nigatu,2016) stating that Arbaminch zuria is with more population pressure but aware of the risks from chemical pesticides than Afar region cotton farms but their main challenge is lack of space for disposal where they perceive land contamination is a serious issues.

The second basic difference was with the awareness of sustainable farming where it is higher in Arbaminch area(5**%)** compared to Afar region especially to Gewane district(34**%)** since training, source of information and educational level of farmers is quit lower than the other districts. This impact is reflected on their lower perception of alternative pest management practices which they rated as their primary constraint. The same is true on shortage of pesticides to the afar farmers which are also one of the top three concerns since they don't practice organic or any other sustainable alternative practice to chemical pesticides like the Arbaminch farms who got training through PAN-Ethiopia and other NGO's.

Whereas, to the major challenge of farmers in Afar region, of the two districts, a "high cost of chemicals" and "Lesser knowledge for chemical free production" were 35% and 34% for Amibara and Gewane districts respectively.

Regarding farmers' least challenges, "the Enforcement of regulatory measures available occupational and environmental proclamations" was mentioned as very lesser challenge by the farmers from both the Amibara (3%) and Gewane (2%) districts as they have lesser knowledge for the need of government enforcement. In contrast Arbaminch farmers(10 %) of them are always trying to solve such enviromental risk through government low enforcement since they have knowledge of risks from chemical pesticides. .This opinion can be explained as Arbaminch farmers with longer practice of organic cotton farms always asking for reinforcement any available measures through government body according the 1995, environmental proclamation of Ethiopia. So it's considered as challenge for them to get an advisory or low enforcement service.

4.2.2. Farmers' Perception towards the risk of chemical pesticide applications

Farmers' Perception towards the risk of chemical pesticide applications is presented in table 4.3. Based on the distribution of small scale cotton farms (SSCF) and large scale cotton farms (LSCF).

Table 4.3 Mean and distribution of responses for statements relating to farmers' perceptions of pesticide risks farmers' perceptions of pesticide risks in a Likert scale.

	Statements		**LSCF(n=71) %**				
No	Statement	Mean Score	Strongly Agree	Agree	Average	Disagree	Strongly disagree
1	Chemical pesticide can cause aerial/land Pollution &Contamination	3.61a	-	48.3	12.2	32.5	7.0
2	There is poisoning and causality due to extensive use of pesticide	4.42	12.6	69.1	15.2	3.1	-
3	There is contamination of food like oil, meat and dairy products from animals	3.52	1.1	47.1	35.6-	17.2-	-
4	Pesticide chemical residue lead to chronic disease with cancer in fertility, dizziness	3.35	13.3	35.7	41.4	9.6	
5	High risks and cost of chemical pesticide is not economically productive	2.69	2.2	34.3.	10.2	43.3	
	Average Awareness Index 3.52						
			SSCF(n=191) %				
No	**Statement**	**Mean score**	Strongly Agree	Agree	Average	Disagree	Strongly disagree
1	Chemical pesticide can cause aerial/land Pollution &Contamination	2.32a	0	22.7	32.3	42.6	2.8
2	There is poisoning and causality due to extensive use of pesticide	3.52	12.1	61.4	10.9	15.5	0
3	There is contamination of food like oil, meat and dairy products from animals	2.23	0	0	42.3	57.6	0
4	Pesticide chemical residue lead to chronic disease with cancer in fertility, dizziness	1.75	0	0	23.2	44.5	24.73
5	High risks and cost of chemical pesticide is not economically productive	2.41	0	5.2	44.3	41.5	9.3
	Average Awareness Index 2.44						

a=Mean perception scores of all respondents based on a five-point Likert-type scale from 1 to 5: here as Strongly Disagree (SD) =1, Disagree (D) =2, Neutral (N) =3, Agree (A) =4 and Strongly Agree (SA) =5" scale. Source:

Source:: Own Survey result (2020).

The total means score of the five awareness questions on farmers' perceptions of pesticide risks and use was 3.52 and 2.44 for LSCF and SSCF respectively, thus indicating that, almost unaware of the statements describing the precautionary measures taken by respondent farmers. The most agreed statements (SA or A) in the LSCF and SSCF is “pesticides cause food poisoning to man and domestic animals” with 81.7% and 73.5% respectively.

The farmers’ mean score result of these most agreed precautionary statement was 4.42 and 3.52 for LSCF and SSCF respectively. The lowest mean score was obtained in the statements” High risks and cost of chemical pesticide is not economically productive (2.69)” for LSCF “and “safety to wild life (1.75)” for SSCF.

Table 4.3 illustrates the result of the Likert scale on the level of agreement to farmer’s risk perception to chemical pesticides applications.

The main reason for the high score on LSCF is due to level of education and number of LSCF are members of cotton association where they can get some trainings and orientation on pesticides precautionary measures. However it doesn’t mean that high score of LSCF are the adopting group since adoption of APMP depends on different factors like attitudes, districts, farm sizes, economic importance and etc. According to this finding we can infer that SSCF are more vulnerable to chemical pesticides even though they the group who are mostly practicing APMP due to its manageability in small farm size and high cost of chemical pesticide relatively incurred to SSCF.
This finding indicates (Table 4.3) the awareness of pesticides risk is slightly below neutral or its between disagree(slightly risky) to neutral(moderately risky) which can be supported by (Legesse,2016) stating more than seventy five percent of farmers in rift valley areas are victim of chemical pesticides and also non-users /adopter of alternative practices to chemical pesticides.

This study also shows that farmer’s average awareness to chemical pesticides risk, where also proved that their storage and disposal management to be very poor for reaffirming their poor awareness of risks on chemical pesticides. If there is responsible pesticides usage; then this would further reduce the amount of money the farmer spends on excess pesticides. This money and other resources could consequently, be used in other income generating venture.

4.3. Attitudes and perception of farmers towards Alternative Pest Management Practices (APMP)

4.3.1. Attitudes of farmers on adopting alternative pest management practices

Among the total of 262 farmer respondents, there were only 59 farmers who adopt APMP. The distribution with farming systems is presented in table 4.3, where 22 and 37 farmers from LSCF and SSCF respectively. The attitude towards the APMP philosophy was measured by asking the respondents to indicate how strongly they agree or disagree with the six statements referring to the APMP philosophy (source). These statements referred to the economic advantage in using APMP, safety reasons in using this practice, more requirements of time, environment protection, and substitution effect (time/economic input).

The overall means for both groups were observed to be 2.98 and 2.92. Both values as illustrated in the attached Annex IV section of this paper, indicates the level of agreement that was between the "disagree" and "agree" levels where it's close to agree. Data in table 4.4. reveals that no item had a mean of 4, and only three items had a mean of 3 or above. SSCF agreed with statements 1, 2 and 4, which refer to an economic advantage, personal safety and to protect the environment reason about preferring alternative pest management practices in cotton, and preference of alternatives based on protection of the environment.

Table 4.4. Descriptive results (mean & std.D.) relating to the attitudes of APMP for the tota
59 Adopting farmers

No	Reason Statement	SSCF n=37			LSCF n=22		
			Mean	Std.D.		Mean	Std.D
1	Economic Reason		3.89	0.319		3.88	0.500
2	Personal safety		3.53	0.506		3.56	0.512
3	Lesser time		2.58	0.732		2.69	0.479
4	To protect the environment		3.06	0.630		3.19	0.403
5	Good source of available information		2.69	0.497		2.9	0.750
6	More time but save money		1.80	0.400		1.70	0.460
	Overall mean score =2.95						

Source: Author own compilation, 2020.

LSCF rated these three statements similar to that of the LSCF. Statement 1 (the economic advantage of alternative practices) had a slightly higher mean for SSCF than LSCF, while preference an alternative practice based on personal safety reasons was ranked similarly (3.56 and 3.53) by LSCF and SSCFs respectively. Statement 6 explored the possibility of substituting economic input by time. This statement had a mean value closer to the disagree point for the SSCF than LSCF.

More requirement of time for the alternative pest management strategy was evaluated in statement 5. Both groups slightly disagreed but not agreed that alternative pest management does not require too much time.

The greatest variability of opinion, indicated by standard deviations, was found for both groups of respondents in the responses to statements which refer to the preference of alternative pest management practices based on personal safety reasons and the possibility that alternative pest management requires more time. The lowest variability was found among the responses of LSCF for the statement related to the protection of the environment while for SSCF respondents the lowest variability's was obtained for their reason of economic advantage in preferring alternative practices to chemical peptides. This finding is also supported by (Niemiera and Lombardi, 2006) stating environmental concern and economic advantages are the key factors in determining the adoption of environmentally friendly pest management practice or to use IPM practice as sustainable management practices.

4.3.2. Perceptions of farmers towards Alternative Pest Management Practices (APMP)

This section presents the study participants' perceptions relating to APMP. The respondents were asked to rate, using a five-point Likert scale, their level of agreement with 15 statements. The descriptors of the scale were as follows: 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree.

Fifteen statements as illustrated in the attachment of the annex II section was selected and Likert scale was implemented to obtain the following results to examine farmers' perception on alternative pest management practices to alternative pest management practices (APMP).

Annex II showing shows the level of agreement, mean, standard deviation and and p-value for the whole farm which we can compare the total respondent's distribution variability and the willingness and favorability of farmers in practicing and perceiving the different variables in APMP, their risk or tolerance for decision of pest management and their perception of pesticides chemicals.

Regarding distribution for level of agreement in the alternative category lower mean score (1.33) and (3.14) for SSCF's and (1.7) and (3.12) for LSCF's was observed in the statement "using nontraditional biological like BT cotton and "Beneficial organisms keep pests at low levels. This perception of farmers scores is one of the reasons for getting a greater number of farmers in the medium perception since there score is greater than strongly disagree and disagree level but lower than Agree (as attached on Appendix B2). we might understand from these two related types of statements that focus on biological control system, farmers are indifferent or disagreement in biological control methods since it requires some sort of better scientific knowledge unlike the cultural or physical control methods which is also supported by (Geovani,2006) explaining sustainable pest management requires intensive management and knowledge of different practices. Within the pesticide category, for SSCF responses to the statements, "Chemical control provides independence" produced mean values of (2.78) and (3.34) for SSCF and LSCF respectively. This finding is also supported by (Apple, 2011) stating that LSCF mostly rely on chemical pesticides due to the risk and loss they expect from high yield of cotton, so that they purchase and apply a greater number of chemical pesticides to their assumption of chemical control provides them their independence of the coming risk by bing applying it continuously.

Perception level: Farmers' perception was the main focus of the study and to determine this, an overall perception score was calculated for each farmer by summing his/her scores. These scores of the respondent could range from 19 - 69, against the possible range of 15 to 75. Based on the perception score, the farmers were divided into three categories. The numbers of respondents who gain score up to 35, their perception level was treated as low; lies between 36 and 55 were medium and above 55 were considered as high. Though farmers' perception level was treated as a continuous variable but for an interpretation there made three categories by dividing three equal distances of the ranges (15 to 75). Furthermore, an overall perception score was calculated for each farmer by summing up the respondents' scores. These scores of the respondent were in the range of 19 - 69, against the possible range of 15 to 75 with an average(mean) of 42.01 and the standard deviation of 11.21 (Table 4.5).

Table 4.5 shows level of perception for the total of 262 respondents by grouping into: Lower, medium and higher perception to farmers' level of perception towards adopting alternative pest management practices.

Table 4.5. Distribution of the total respondents according to their perception score (N=262)

Categories	Number	Percent	Possible Range	Observed Range	Mean	
Low perception	**91**	**34.7**				
(Up to 35 score)						
Medium perception	**133**	**50.7**	**15-75**	**19-69**	**42.01**	**11.21**
(36-55 score)						
High perception	**38**	**14.5**				
(Above 56 score)						

Source: Own Survey result (2020).

The result is supported by the study (Apple and Van Ransburg, 2011) that applied a total of 21 perception statements on sustainable agriculture and found majority of the perception statement under low and medium category.

4.4. Determinants of adoption for the APMP's

4.4.1. Adoption of alternative pest management practices

With regard to adoption of alternatives to chemical pesticides (table 4.6), only 24.9% of the SSCF respondents mentioned at least one of the alternatives unlike LSCF (20.1%) that implies only 22.5%, which is below one quarter of cotton growers in the three districts implementing APMP. This result is a signal for governmental offices and policy makers how more than 75% our cotton growers are in a risk of environmental contamination and health issues through their application of chemical pesticides. This finding is supported by other studies with chemical pesticide (Ministry of health, 2018, PAN-Ethiopia, 2017 & Nigatu, 2016), where it was reported more than 75%-80% of farmers in Ethiopia are potentially in a risk of health and environmental consequences of chemical pesticides application.

Table 4.6. Farmer's adoption of alternative pest management practices

No	Statement	SSCF (n=71)	LSCF(n=191)
		%	%
1	Farmers who mentioned at least one alternative to chemical pesticides	24.9	20.1
2	Cultural/Agronomic practice (i.e., crop rotation, multi cropping, improved, etc.) farmers actively implementing on their	20.3	16.1
3	Physical/Mechanical practices (manual weeding, mulching, etc.)	21.2	15.5
4	Bio pesticides practices (/insect trapping)	19.3	13.3
5	Biological species/modern alternatives like BT crops	-	-
6	Any other//Integrated pest management	11.2	15.4

Source: Own survey result (2020).

With most of the farmers (21.2%) from SSCF mentioning physical and mechanical practices like manual weeding as an alternative followed by Cultural/Agronomic practices like crop rotation, and multi cropping (20.3%). Regarding to LSCF, the survey illustrated as Cultural/Agronomic practices like crop rotation, multi cropping (16.1%) followed by mentioning physical and mechanical practices like manual weeding as an alternative (15.5). None of the farmers in both farming types in the surveyed farms mentioned nontraditional like BT cotton control practice or biological as an alternative to chemical pesticides since it's in a trial level in research center after the government approved BT cotton last year in 2020(MOA,2020). The main objective of this study was to identify the influencing factors for adoption of APMP, where there was a need to measure the extent to which practices related to alternative pest management to chemical pesticides were adopted among farmers in the three districts of Arbaminch, Amibara and Gewane areas. In order to achieve this goal, 10 agricultural practices were studied. These practices are listed in the attachment (annex III) with farmer's level of adoption with Likert scale questions with the 10 selected APMP or strategies. The survey as illustrated in the annex III, the level of adoption of each practice expressed by the respondents using a scale from 1 to 99 points, as mentioned earlier in the empirical analysis/analytical frame work.as indicated in the data analysis section

Hence, farmer's perception to the extent of APMP adoption as: *1=Never, 2=Seldom, 3=frequently, 4=very frequently, 5=Always*, where the questions include "How often you rotate", and other alternative management practices.

Analysis of the data as displayed in the attached annex III, revealed that there were only one practices for LSCF and four practices for SSCF were reported as being used frequently (50 points) to very frequently (90 points). The practice with highest rating among both groups of respondents was using manual weeding. The lowest rating was observed for using nontraditional pesticides. Only the practice "use of mulching", and "adjust your planting date to avoid risk of pest damages" had a value less than 30 or "*Never*". As indicated on the attached annex III, five practices for the LSCF group and three practices for SSCF group were observed in the range of 30 to 40 or "*Seldom*".

As indicated in the result (table 4.6), the lesser percentage of respondents was obtained on the pest management practices (for statement 6) from both farm types, where more respondents from LSCF (15.4%) replied yes by stating IPM. Whereas, only 11.2% of SSCF stated they use some kinds of IPM techniques. The main reason why SSCF are using lesser percentage of IPM or any other practice is not quite sure of the name IPM due to the nature of IPM which is an integrated pest management as the name indicates. IPM requires skill on assessment of pest scouting, awareness of some of ingredients in the chemical constitutes and some calculation of threshold and other knowledge seeking tasks. This finding coincides with PAN-UK, 2018 report on chemical pesticides that IPM is a common practice in the western world since it requires some skills on chemicals and analysis of some descriptive statistics like percentage and others. Hence the above key concept of IPM is the major reason why the researcher decided to study other affordable and adaptable strategies in developing countries like sustainable alternative to chemical pesticides which should be given priority in the context of Ethiopian cotton farmers.

Model Fitness test

The econometric analysis was conducted using Stata 14; prior to the analysis, the model was checked for multicollinearity. Accordingly, the value of Variance Inflation Factor (VIF) for continuous variables was 1.63, which is less than 5 and Contingency Coefficient for Discrete Variables is less than 0.75 shows that multicollinearity is not a serious problem.

The estimated coefficients of the bivariate probit models are shown in Table 4.6. However, the likelihood ratio test of ρ is significant and positive (1.79) with a significant Wald Chi-squared test value (66.36) that allows us to reject the H_0 of conjoint nullity of the variables included in the estimation. Using bivariate probit specification on mentioned with 262 observations, a full information maximum likelihood was used for estimation. Estimates are exhibited in Table 4. 7. The significance level chosen for this analysis was 0.10. Rho is significant at 1%, indicating that a bivariate probit model rather than two univariate probit is more appropriate.

4.4.2. Estimated parameters of bivariate models

The results show seven variables that are significantly affecting the adoption for both types of practices (ACCM and BCM) as an alternative pest management practice include the cotton farm size, land tenure (land ownership status), training on APMP, distance from nearby market, perception of risks from chemical pesticide applications, districts (geographical location), and the risk aversion attitude of farmers for the adoption of APMP. Whereas variables like ext. Contact and share of income are significant at 5% and 1% level of significance for CACM respectively. Whereas the variable age and educational level of farmers is only significant at 1% level of significance to BCM. The result of marginal effects for both ACCM and BCM shows that all the above significant levels for both types of practices to be marginally significant. In contrast Extension contact and share of income from cotton farming are only marginally significant to CACM while age and educational level of cotton growing farmers is significant to BCM's. To have brief view, the analysis result was explicitly discussed below:

Table 4.7. indicates that the dependent variables in the Bivariate probit model of Cultural/Agronomic practices (binary or dummy) takes the value 1 if adopt cultural and agronomic, 0 otherwise biological control methods(binary) take value 1 if adopt biological practices, 0 otherwise.

Table 4.7. Estimated parameter of bivariate probit model for the adoption of APMP (Cultural/Agronomic and Biological control methods)

	Bivariate Probit Approach		Marginal Effects	
No. Explanatory Variables	**Agronomic/cultural Methods/practices**	**Biological Methods**	**Agronomic/cultural Methods/practices**	**Biological Methods**
Farmer characteristics				
1. Age	-0.1302	**-0.0484** ***	-0.0043	-0.0047***
	(0.0086)	(0.0048)	(0.0029)	(0.0030)
2. Education	0.1642	**0.1858*** **	0.0427	0.0648***
	(0.0265)	(0.0272)	(0.0068)	(0.0092)
3. Farm Exp.	0.0203	0.1203	0.0782	0.0147
	(0.1024)	(0.1023)	(0.0573)	(0.0061)
4. Share of cotton income	**-0.0582** **	0.0960	-0.0213**	0.0350
	0.1367	0.1341	0.0485	0.0503
Institutional Factors				
5. Farm Size	0.0105***	-0.0069***	0.0037***	-0.0026***
	(0.0025)	(0.0022)	(0.008)	(0.008)
6. Land Tenure	1.2374***	1.1590***	0.3243***	0.3732***
(Land holding)	0.1277	0.1377	0.0328	0.041
7. Ext. Contact	**0.2367** ***	0.2952	0.0762***	0.1393
	0.1379	0.1357	0.0388	0.0521
8.Training of	0.1016**	0.0109**	0.0218**	0.0078**
APMP	0.0333	0.0288	0.0086	0.0097
Biophysical Factors				
9.. District/location	-1.1590***	-1.2374**	0.3732***	-0.3243**
	0.1347	0.1277	0.0411	0.0328
10.**Market** distance	-0.0956***	-0.0184**	-0.0047***	-0.0943**
	0.0124	0.1470	0.009	0.0056
Behavioral Factors				
11. PercpnRisk of	0.2367*	0.2952**	0.0762***	0.1393***
chemicals	0.1309	0.1435	0.0388	0.0521
12. Attitudes of	0.1642***	0.1858***	0.0427***	0.0648***
Adoption	0.0265	0.0272	0.0068	0.0092
Constant	4.2476***	3.9436***	-	-
	(0.6190)	(0.6731)		
Log likelihood	-511.59			
LR test $\chi2(12)$	-		--	-
Pseudo-R2	-		-	-
Wald$\chi2(27)$	66.39***		-	-
LR test of ρ=0, $\chi2(1)$	1.79*		-	-
Correlation Coefficient	0.4058***		-	-
Total respondents	262		-	-

Note: Data in parentheses are standard errors. Statistical significance level is presented as *(!0%), ** (5%) ,and ***(1 %).

Source: Authors' calculation based on own survey data during April–August

4.4.2.1. Factors influencing adoption of APMP (CACM and BCM)

***Training on APMP*:** Training on APMP is significant at 1% level and its positive sign indicates that, farmers with access to training on APMP from different organizations are more likely to adopt the APMP as compared to those farmers who do not get access to trainings on APMP regularly.

The farmers who receive training on APMP have more chance to practice APMP farming to control pests. Farmers from Arbaminch can be good evidence of APMP adopters who are more aware of environmentally sustainable pest management and other related farm practices due to different institutions practicing in the area including the PAN-Ethiopia organic farming practices. This finding is also supported by (Giller et al., 2009; Kassam et al., 2009; Derpsch, 2007; Friedrich et al., 2010), stating that lack of proper conservation agriculture knowledge is reported among the barriers to environmentally sustainable farming practices or conservation agriculture (CA) adoption.

***Perception of Risks chemical pesticides*:** It is stated that farmers perception of chemical pesticides risk to be Positively Significant at 10% and 5% for CACM and BCM respectively.

This result is consistent with (Wang et al., 2017) revealing that farmer`s awareness of risks and other Socioeconomic characteristics in china were found to have a substantial influence on their precautionary behaviors and adoption status of alternative pest management practice (Wang et al., 2017).

Farmer’s pesticide risk perception, the primary source of information on pesticide and other socio-economic characteristic have been found to play a role in influencing farmer’s behavior in pesticides use (Jin et al., 2014; Damalas and Abdollahzadeh, 2016). For example, farmers who took precautionary measures for pesticide risks are more likely to adopt alternative practices (Damalas and Hashmi, 2010).

Farm size: Farm size is positively and negatively significant for CACM and BCM at 1% level respectively the positive influence of farm size on the adoption of alternative practice like CACM once can be explained with the farmers’ need and requirement of the CACM’s careful and reduced use of some farm inputs such as irrigation, fertilizers, and pesticides while maintaining the yield levels. The farmers are skeptical to reduce the farm input use and consider it a risk (Zulfiqar and Thapa, 2016). A large farm size provides a cushion to the farmers to take on these risky decisions (Khanna, 2001). Other CACM practices whose adoption is aided by farm size included soil nutrient testing and use of appropriate safety equipment by the person applying pesticides.

In contrast the negative coefficient for BCM can be explained as management of larger farmer for BCM could be difficult due to the input scarcity for biological methods and intense management required unlike larger cotton farms. (Riwthong et al., 2016),

Thus, a farmer with more farm area is expected to adopt more of CACM since it has large farm area to practice multi cropping and crop rotation activities which are components of CACM.

In contrast to BCM its positively significant since managing small size of cotton farm land is easy for BCM practices.

***Attitudes to the risk of APMP adoption*:** Attitudes to the risk of APMP adoption has a positive coefficient and significant at 1% level for both CACM and BCM which implies that, farmers with familiarities on adoption of APMP regardless of the available risks are more likely to adopt the APMP as compared to those with risk averse farmers who don't take the risk of adoption due to many reasons. It is assumed that those farmers with high interest and familiar to alternative pest management practices could benefit in the long run from the sustainable practices they are operating in their farm fields to increase the safety of their health status and the bad consequence of environmental risk from chemical pesticides application to their cotton farms. Farmers with negative attitude or lesser familiarity to APMP are less likely to adopt due the fear of short-term yield decrease and lack of information on the sustainability of alternative pest management practices. This finding is also consistent with (Riwthong et al., 2016), stating that the farmer`s decision to adopt agricultural technology is influenced by the farmer`s attitude towards that technology which is in turn influenced by knowledge about the technology. This can be attributed to lack of knowledge on associated health and environmental risks and wrong perception about pesticide use can lead farmers on the possible response of farmers to other crop protection technologies.

***Distance from nearest Market*:** The variable DISMARKT is significant for both CCAM and BCM at 1% level and its negative sign indicates that, farmers who don't have access to nearby market are less likely to adopt both types of alternative pest management practices (CACM and BCM) as compared to those farmers who get nearby market access with a shorter distance to their cotton farm. The farmers who are nearer to market access and located in the humid dry (kola) are those practicing APMP and have more chance to practice APMP as illustrated in the bivariate probit model (table 4.7). Furthermore, additional reasons such as the case of Arbaminch zuria cotton farmers who are more aware of environmentally sustainable pest management practices due to their close contact to PAN-Ethiopia organization, might be the other case for getting more adopter in this district. This finding is also supported by (Feleke, S. and Zegeye, T, 2005) indicating that the negative and significant association of market distance with the adoption of new farm practices like improved maize. This result indicates that a farmer living at a distance from market centers is less likely to adopt APMP than those who are located closer. Thus, it is expected that the closer the local market is, the higher the probability of APMP adoption (Khan, 2009).

Hence for further implications, this result indicates that farmers who are more likely to adopt, in general are town based with respect to agricultural products and sources of information. It implies that when planning interventions related to APMP, distance to town markets matters, perhaps due to marketing opportunities for cotton products, ease of access to information, or some other reason. If widespread APMP adoption is desired, it may be necessary to address the distance constraint.

Land tenure rights: The result shows that a land tenure right is positively significant in either of the CACM and BCM. As expected, farmers with permanent land rights have the lowest probability of pesticide use since they invest in different environmental protection activities like planting trees and soil conservation practices in terracing on their own farm land. This finding is consistent with (Nicolopoulou et al., 2016), explaining the land ownership status of farmers is influential factor to make their own decision on their own land for the adoption of new farming practices.

DISTRICT/Regional locations: Geographical factors like the difference in district were another factor responsible for the adoption of both CACM and BCM practices in the study area. The result shows a negatively significant at 1% and 5%level respectively. The significance and negative coefficient of Arid and semiarid region of the Afar region of the two districts (Amibara and Gewane) can be explained as those farmers who operate in arid and semiarid lowland areas (dry kola) of Afar region are less likely to adopt as compared to the humid lowland (moist kola) areas of Arbaminch zuria areas of cotton farms. This scenario can be also justified as, the relative higher altitudes of Arbaminch zuria districts are more favorable to different kinds of crops which are one criterion of AMPM (shifting cultivation) and also due to its nearest distance to the main road access to information and source of pest management is much better than any of the two Afar districts. This finding is in line with (Baptistia and Swan, 1998) stating that the pressure from social emulation and localized competition in multiple crops growing areas encourages farmers to adopt new and profitable technologies.

Furthermore, the organic farming projects in Arbaminch zuria districts since 2013 on sustainable cotton and pest management farming practices with PAN-Ethiopia played significant role for the increment of the rate of adoption. PAN-Ethiopia is an NGO working on pesticide network according its name and playing a key role in Arbaminch zuria small cotton farms through training more than 2000 cotton farmers, even their experience is assimilated to the larger cotton farmers in the area. According to survey data, even Arbaminch large commercial cotton farms are showing more familiarity/favorableness to APMP than the other two selected districts in Afar region. This finding is practical and deeply explained in PAN-Ethiopia yearly bulletin of 2015-2020 in addition to the observed farmers in Arbaminch zuria districts.

In contrast some variables like share of income and extension contact for CACM and farmer's age and education for BCM are separately significant where the possible explanation could be:

The share of income was another factor responsible for an increase in the adoption of only CAM technologies practiced by the farmers in the study area. Income share of cotton farm operation is negatively significant in CACM since the more income from non-cotton production decreases the components of CACM practices like multi cropping and crop rotation activities. In contrast to BCM practitioners, as their farm size is smaller it tends to be insignificant to obtain diversified income which make them unable to practice different crops to increase their income. This finding is in line with (Pitt and Sumodiningrat, 1991) stating that, farmers with more alternative income sources of agricultural production have higher income diversity and are more willing to invest in riskier (new) technologies. The more income sources, such as practicing multi-cropping practices make farmers less risk-averse.

Extension contacts: The number of extension contact/visit to of Cotton growing farmer is positive significant at 1% for only to CACM's. Similarly, it has also a positive coefficient but insignificant level to BCM practices. The positive sign of the coefficient for the extension contacts of farmers indicates that, the more visited farmers through extension agents are more likely to adopt the alternative pest management practices of CACM which can be explained as extension agents are focused on CACM than BCM's. This finding is consistent with (Rahelizatovo and Gillespie, 2004) that indicates an increased information access from formal sources (government extension agents) has shown an increase in the number of alternative pest management practices adopted. The studies on adoption of innovation and diffusion have long established the correlation between information access and adoption (Traor_e et al., 1998). It becomes even more important as the extent of complexity of technology increases (Nowak, 1987).

Age: The age of Cotton growing farmer is negatively significant at 1% for only to BCM practices. Similarly, it has also a negative coefficient but insignificant level to ACM practices. The negative sign of the coefficient for the age of farmers indicates that, the old farmers are less likely to adopt the alternative practices to chemical pesticides application practices or activities as compared to young category of farmers. Past studies (Alavalapati et al., 1995), indicates as it may also be that younger farmers are more likely to adopt new technologies and/or are more likely to be early adopters. Young people have more energy, and it's more important for them to invest in the long-term productivity. This result and finding are also in line with Damalas (2015), stating that elders are more resistant to newer farm practices and more risk averse to non-conventional farm practices.

Education**:** The farmers' education had a significant and positive effect (at 1%) on the adoption of BCM because a higher education level implied a greater level of knowledge and analytical capability (Zulfiqar and Thapa, 2016). Therefore, the farmers with higher education adopt any new knowledge or technology earlier than others (Athipanyakul and Pak-Uthai, 2012; Huffman, 2001; Krasuaythong, 2008). It is clear that as the level of education increases the farmers' exposure to new ideas and information increased and hence, enables the household head to adopt alternative pest management practices. Education was also expected to influence APMP adoption positively in the previous section of the empirical analysis. However, level of education is also positive coefficient for ACM even though it's not significant which implies some cultural activities can be learned through experience without formal educational level.

The education level was specifically very important in the adoption of BCM since these practices involve the use of concepts about beneficiary organisms as well as other knowledge of an intensive technology which are not easily understandable for an uneducated farmer **(**Riwthong et al., 2016).

4.4.2.2. The Marginal Effects for the Bivariate Model

In this section we focus our discussion on the bivariate probit marginal effects reported in Table 6. As previously noted, these marginal effects analysis offers the analytical benefit of allowing us to consider the effects of each explanatory variable on the four observed schoolwork outcomes. The bivariate probit approach allows us to calculate the conditional marginal effects (i.e., marginal effects conditional on the adoption of the other pest management method/practice) unlike the individual probit approach which does not allow such calculation (Velandia et al. 2009).

The econometric analysis was conducted using Stata 14; where the result of variables from both CACM and BCM shows show that variables like Education, Training on APMP, Farm size, Attitudes/risks for adoption, Market Distance, Districts, and Land tenure to be marginally significant. In contrast Extension contact and share of income from cotton farming are only significant to CACM while the variable age and education level is significant to BCM's. The detail explanations on each variable are presented below in the following discussion parts.

Training on APMP**:** The results show that the marginal effect of farmers' level of trading for APMP's is positively significant at 5% level of significance for both types of alternative pest management practices. However, in terms of magnitude the effect on the outcome for CACM (0.0218) is more significant than the BCM (0.0078). The interpretation of this is that the returns to alternative pest management trainings in terms of the probability of adoption are higher for CACM. Our results show that for a 1% increase of recommended training level to those who attend trainings, the associated adoption rate is more likely to rise by 6.5% and 4.3% for BCM and CACM respectively**.** This finding is consistent with Thirtle et al., 2003), indicating the explanation for this scenario thereby through encouraging the use of new technologies such as "better cotton". It was found that an increase in the availability of information and trainings from formal sources increased the intensity of adoption for environmentally sustainable pest management practices.

Farm size: The results show that the marginal effect of farmers' cotton farm size for the adoption of APMP's **is** positively and negatively significant at 1% level for CCM and BCM respectively. Our results show that for a 1 hectare increase in cotton farm size the adoption rate for CACM is more likely to rise by 0.4% and decrease of 0.3% for BCM**.** The explanation for this scenario could be as the farm size increase the farmers tends to increase multi cropping and shifting cultivation which are components of Acini contrast large size cotton farms are difficult to operate and manage BCM practices like implementation of bio pesticides and beneficial insects. This finding is in line with (Feleke, S. and Zegeye, T, 2005), indicating that smaller cotton farms are easily manageable for intensive pest management practices like the BCM practices.

Attitudes/risks for adoption: The results show that the marginal effect of farmers' cotton farmers' attitude or familiarity for the adoption of both types of APMP's is positively significant at 1% level. However, in terms of magnitude, the effect of the outcome for BCM (0.0648) is more significant than the CACM (0.0427). Our results show that for a 1% increase of farmers' familiarity or positive attitudes for APMP's, the probability of adoption is more likely to rise by 6.5% and 4.3% for BCM and CACM**.** The explanation for this scenario could be as farmers with negative attitude or lesser familiarity to APMP are less likely to adopt due the fear of short-term yield decrease and lack of information on the sustainability of alternative pest management practices .This finding is also consistent with (Riwthong et al., 2016), stating that the farmer`s decision to adopt agricultural technology is influenced by the farmer`s attitude towards that technology which is in turn influenced by knowledge about the technology.

Market Distance: The results show that the marginal effect of farmers' cotton farmers' home/market distances for adoption of both types of APMP's **is** negatively significant at 1% level**.** Our results show that for a 1km increase of farmers home/market distance from their cotton farm, the probability of adoption is more likely to decrease by 9as .4 % and 0.4% for BCM and CACM respectively. The explanation for this scenario could be, as the negative direction indicates that farmers whose farms were close to the market areas were more likely to adopt APMP than those who comparatively stayed far away. The result is quite rational as (Nigatu, 2016) indicates farmers in Arbaminch zuria area where market access is better than afar cotton farms in practicing different kinds of sustainable alternative pest management practices.

Districts: The results show that the marginal effect of farmers' district or regional location of their cotton farms for the adoption of both types of APMP's **is** negatively significant at 5% level for both CACM and BCM. Our results show that for every additional cotton farms located in Afar region (Amibara and Gewane districts) it is more likely to decrease by 32% and 37% decrease of farmers adoption of BCM and CACM respectively .Farmers who operate in arid and semiarid lowland areas (dry kola) of Afar region are less likely to adopt as compared to the humid lowland (moist kola) areas of Arbaminch zuria areas of cotton farms. The possible explanation for this can be the relatively higher altitudes of Arbaminch zuria districts are more favorable to different kinds of crops which is one criterion of AMPM (shifting cultivation) and also due to its nearest distance to the main road access to information and source of pest management is much better than any of the two Afar districts. This finding is in line with (Baptistia and Swan, 1998) stating that the pressure from social emulation and localized competition in multiple crops growing areas encourages farmers to adopt new and profitable technologies.

Land tenure: The results show that the marginal effect of farmers' cotton farmers' land tenure or land ownership status on the adoption of APMP's **is** positively significant at 1% level for both CACM and BCM**.** Our results show that for each one percent increase in land holding status of each cotton farm, the probability of adoption is more likely to rise by 32.4% for CACM and 37% for BCM practices**.** The explanation for this scenario could be as expected; farmers with permanent land rights have the lowest probability pesticide use. Farmers with permanent land rights often take into account the negative long-term effect of chemical input use. Also, due to the fact that permanent rights enable the use of soil regeneration and pest control alternatives such as the planting of trees, it is less likely that chemical inputs will be used on permanent land rights compared to temporary land rights (Jin et al., 2014; Damalas and Abdollahzadeh, 2016).

In contrast the marginally significance level for a single pest management practice like the age and education for BCM and extension contact and share of income from cotton farming for CACM practices can be justified in the following way:

Education*:* The results show that the marginal effect of farmers' level of education is positively significant at 1% level of significance only for BCM of alternative pest management practices. Even though not significant for CACM it has a positive coefficient (0.0427) but lower than BCM

(0.0648). The analysis result explicitly shows that level of education has an effect on adoption of APMP. Accordingly, as level of education increased, respondents are more likely to adopt both types of APMP's. Our results show that when the educational level of respondent increase by one year, the associated adoption rate is more likely to rise by 6.5% for BCM. When all educational level compared with below and primary school completed (Base variable) was more likely to adopt the mentioned APMP's. Similar studies also shows that a positive relationship between education and adoption of an environmentally sustainable pest management practice (Ashfaq et al. 2008; Kouamé 2011 Ullah et al. 2015; Ping et al. 2016; Saqib et al. 2016a).

Extension contacts: The number of extension contact/visit to of Cotton growing farmer is positive significant at 1% for only to CACM's. Our results show that for a 1% increase of number of extension visitors to cotton farmers', the associated adoption rate is more likely to rise by 7.6%. The explanation for this scenario could be as extension agents are focused on CACM than BCM's. This finding is consistent with (Rahelizatovo and Gillespie, 2004) that indicates an increased information access from formal sources (government extension agents) has shown an increase in the number of alternative pest management technologies or practices adopted.

Share of income from cotton farm: The results show that the marginal effect of farmers' cotton farmers' Share of income from cotton farming on the adoption of APMP's is negatively significant at 1% level for CACM only. Our results show that for each percent increase in cotton crops income with relation to other crops in the field is more likely to decrease by 2.1% for the adoption ACM. In other words, the share of additional income other than only cotton production among the total income was the most significant factor that increased the number of adopted CACM practices.by 2.1% with each one percent increase in other crops share in income (Table 4.7).

The positive contribution of income sources other than farm income towards technology adoption can be explained in the context of the availability of diverse income sources and consequent freedom to take risks in adopting new technologies. The farmers with more livestock holdings have higher income diversity and are more willing to invest in riskier (new) technologies (Pitt and Sumodiningrat, 1991). The more income sources from other crops other than cotton production make farmers less risk-averse where the farmer tend to be more likely to adopt different kinds of APMP's like CACM.

The variable age was explained in the factors of adoption section of 4.4.2.1. above.

4.4.3. Factors hindering adoption of APMP

The majority of the farmers did not adopt the three types of (cultural/agronomic, physical/ mechanical, and biological control methods) as mentioned in the descriptive part (table 4.1) which states 76.6% are non-adopters until the 2019/20 crop year. They were requested to mention the basic and common reasons that hindered them not to adopt, through providing the common challenges as listed here in table 4.8.

Among 203 non-adopter respondent farmers who were asked for not adopting APMP against the conventional pesticide application, four were voted by the majority as more than 70% of their challenges from the given seven causes that may be a problem hindering them not to adopt the practices. The above four main challenges include, Lack of information/policy (94%), Lack of awareness (87%), Inability to use the technology (72%), and not getting ready in short time (71%) ranking 1^{st} to 4^{th} respectively. Table 4.8 demonstrates list of challenges farmers are facing in the selected districts that could hinders them in order not to adopt APMP or related strategies.

Table 4.8. Problems hindering adoption of APMP by farmers

S. No variables	non-adopters of alternative practices (APMP)	
	Yes (%)	NO (%)
1 Lack of interest on the Practice	15	85
2 Not get ready in short time	71	29
3 It is expensive to practice	24	76
4 Low in quality/effectiveness	56	44
5 Lack of awareness	87	13
6. Inability to use the technology	72	28
7 Lack of information/policy	94	6

Source: own survey result (2020)

On the other hand, from the total non-adopters who mentioned the least cause of their challenge or hindrances for not adopting APMP from the mention eight causes includes, Lack of interest on the Practice (15%) and it is expensive to practice or cost of practice is higher (24%), ranking 1st and 2nd for least challenge or hindering factors. This finding is supported by (Nigatu,2016), stating the main reasons for farmers in the rift valley and Arbaminch areas not practicing alternative practices was clearly associated to their lack of awareness, training, and encouraging policies and incentives to farming community in the studied areas.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusions

This study assessed the status of adoption and factors influencing adoption of alternative pest management practices (APMP) to chemical pesticides, in Arbaminch zuria, Amibara and Gewane districts in Ethiopia. In addition, environmental and human risks, and exposure to this chemical pesticide was also assessed through identification of knowledge, attitudes and perception level of farmers to these practices. A bivariate probit model was used to analyze data and assess the influencing factor for adoption and estimation probability and marginal effects for the rate of adoption of alternative pest management practices.

Results from this study indicate that awareness of environmental and human health is very low since more than three quarter of respondents didn't agree on the risks at all. The same is true to farmer's awareness on government environmental policies strategies on cotton sector. The perception score indicates that majority of the perception statement to be under low and medium category where more than 85% of the farmers (85.5%) had low to medium level of perception, while high perception on alternative pest management practices was only 14.5%. The bivariate probit model made a revelation that seven variables indicated as determinants of adoption for alternative pest management strategies. Variables such as Districts, training on alternative practice, cotton farm size, distant from nearby market, risk aversion behavior of farmers, are among the main once in influencing APMP adoption for both ACCM and BCM's. The variables age and education level are marginally significant to BCM's, while extension contact and share of income from cotton farming are significant to ACCM's. In contrast farm experience is insignificant in both types of alternative pest management practices implying that none or lesser influencing factors for APMP adoption.

These results suggest that targeting these groups for training educational programs would increase the probabilities of success for adoption strategies. Results of this analysis demonstrated that farmers with more than one crop type within their farm areas adopted a better number of those alternative practices like multi-cropping and crop rotation controlling methods in order to minimize the risk of environment and human health issues. The survey also revealed that cost of chemical pesticides has long been thought of as the primary driver of APMP in the decision of adoption where the results of this study confirm this long-held belief.

5.2. Recommendation and Further research areas

From the aforementioned discussions and conclusions, the following was recommended;

1. The findings with the survey result indicate that the level of training and other source of awareness creation programs would increase the probabilities of success for adoption strategies. Upon considering this scenario, we can infer that farmer should be encouraged to join farmer groups or me membership of related organizations and other social networks to facilitate the exchange of new ideas, information, increase their bargaining power, access vital farm inputs, protective gears, access lucrative markets, credit, and other relevant services at a lower cost.

2. There is a need to understand farmer's perception on alternative practices since what they perceive could be the reasons for continuing the conventional practice of chemical pesticides application despite the high risk on health and environment. The same to farmers' attitudes that economic advantage is the main reason for their decision, so there is a need to give training and demonstrations to prove the economic viability of this practice in addition to its conservation of environment and biodiversity as a whole.

3. Policy formulators have therefore misconstrued an increasing supply of chemical pesticides to be an incentive for crop protection but it is a disincentive to APMP adoption and environmental sustainability of farms and health risk of farmers. Farmers' circumstances also affected which technologies they chose to adopt. If farmers' circumstances were favorable, some technologies were selected over others. As shown in the survey's result, it's clear that farmer's adoption risk is dependent in their favorability and familiarity status of the alternative practices to be adopted.

Hence, to public policymakers and other development partners, there is a need for promotion and implementation alternative methods which are tailored towards the needs of the farmers. Fortunately, an alternative pest management practice is an all-inclusive technique where it's cost-effective, eco-friendly, guarantees yields in the long run and contributes towards sustainable agriculture.

Future research should involve both farmers and extension officers from the onset and have inbuilt ways of disseminating the research findings to enhance adoption. This study and other related findings need to be replicated in other parts of cotton and other crop growing areas of Ethiopia in order to improve the level of adoption on APMP and strategies for safer and environmentally sustainable farming systems in particular and for overall development of the rural community in general

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Annexes

Annex-I Questionnaire for Farmers

ADDIS ABABA UNIVERSITY, COLLEGE OF DEVELOPMENT STUDIES

CENTRE FOR ENVIRONMENT AND DEVELOPMENT

Questionnaires to Farmers

The aim of this questionnaire is to gather data for the research titled "Determinants for the Adoption of Alternative Pest Management strategies in Cotton Farms: The case of Arbaminch zuria, Amibara and Gewane districts in Ethiopia". Additionally, it is only used for research purpose; besides any answer you give will be kept confidential. So as your answer has a big value to the achievement of this research. For providing reliable and honest answer thank you a lot.

- You are not expected to write your name
- For questions of choose type, you must only choose one and put (✓) sign in the box of your answer. Whereas, for questions which needs further description please write on the lines given.

Part One: Demographic Data of Respondents

1. What is your age? ________________________________
2. Educational Background
    1. No formal education/primary ☐ 2. Secondary junior/7-8 ☐
    3. Secondary senior/9-12 ☐ 4. College+ ☐

3. What is your Farming Experience?___________________

4. Your farm area size/ha_____________________________

5. Yield per hectare*kg______________________________

6. Distance to the nearest market in km_________________

7. Annual number of sales contract/agreement with direct consumerism number

1. No or once direct/any sales agreement ☐ 2. At least two or more ☐

8. Assessment of credit facility

1. Not Available ☐ 2. Available ☐

9. Assessment of paying record for those available credit facilities

1. Not ☐ 2. Good ☐

10. Size of land owned (in hectare)……….

11. **Share of income from cotton (in percentage)**

1. Cotton ☐ 2. Other crop ☐

12. % of pesticide expense

1. <25% ☐ 2. 25%-50% ☐ 3. 51%-75% ☐ 4. >75% ☐

13. Membership

1. Yes ☐ **2. No** ☐

14. Using Irrigation

1. Yes ☐ 2. No ☐

15. **Risk of chemical pesticide**

1. Yes, taking precaution measure ☐ 2. No, not taking precaution measure ☐

Part Two: Part Two: Likert Scale measurement on Institutional/Behavioral/Regional factors for a Sustainable Alternative pest management practices and Chemical Pesticide Variables

No	A. Level of agreement on the risk occurred/expected	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Chemical pesticide can cause aerial/land pollution & contamination					
2	There is poisoning and causality due to extensive use of pesticide					
3	There is contamination of food like oil, meat and dairy products from animals					
4	Pesticide chemical residue lead to chronic disease with cancer in fertility, dizziness					
5	High cost of chemical pesticide is not economically product					
	B. Level of agreement of respondent's perceptions in a different category i.e., alternative pest management i.e., /risks and pesticides, where1=SD, 2=D,3=Neutral/average,4=Agree and, 5=SA					
	Alternatives	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
6	Beneficial organisms /like insect trapping keep pests at low levels					
7	pest scouting is essential for IPM or other sustainable alternatives					
8	Physical/mechanical means like hand weeding and pruning can reduce rate of pesticide application					
9	Crop rotation reduces risk of crop damage					

10	Adjusting plant date reduces risk of crop damage					
11	Multiple crop can reduce rate of pesticide application					
12	improved/competent variety can reduce my usage of pesticide					
13	Use of nontraditional pesticides like but cotton					
	Tolerance/Risk					
14	Low levels of crop pests are acceptable					
15	It is always not necessary to treat					
16	Killing pests is not the major goal					
	Pesticides					
17	Chemical control is not the only reliable method					
18	Pesticides may not reduce the amount of time					
19	Chemical control may not provide independence					
20	Dead pests may not show effectiveness					
	C. Level of Adoption	**Never**	**Seldom**	**Frequntly**	**Very Frequtly**	**Always**
21	How often you rotate					
22	Intercropping					
23	Mulching					
24	Use of improved crop/commutative/strong varieties					
25	Adjusting planting date					
26	Manual weeding/Pruning					
27	Crop residue destruction					
28	Multi/Mixed cropping					
29	Use of traps					
30	Biological species					

	D. Reason to adopt Familiarity about adopting APMP's, please indicate how	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
31	I find economic advantage in using IPM in my cotton production					
32	I prefer IPM based on personal safety reasons					
33	I like IPM because it does not require too much time					
34	I prefer IPM practices to protect the environment					
35	There are available good sources of information about IPM to use in cotton.					
36	I am interested in using a technology or pest management strategy that requires more time but save money					
	E. Awareness of environmental sustainability perception, policy and stray of safer cotton pest management and strategy using Likert scale level of agreement i.e., my strategy and policy					
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
37	Well aware of government policy, strategy of sustainable cotton production and ecofriendly pest control methods					
38	Can serve us eco balance of pests with other beneficial insects					
39	Can reduce risk on soil					
40	confirmation for Legality of pesticide applied					
41	Training on biodiversity, environmental risk and banned/expired/ pesticide					

Part Three: Semi-structured and Interview questions in the different farming types of cotton farmers about their Awareness, Attitude and knowledge of alternative pest management practices and Adoption status.

A. Information on cotton pest management or crop production

1. Source of pest management information

Neighbors
SELF/Personal observations
Chronological application schedule
Pesticide retailers
Consultant, NGO/Agronomist
Agriculture/Environment Extension Agent
Health Extension Agent
Other/so Please specify

2. Which methods from the list of alternative pest management methods actively in use by farmers?

APMP Statement's	**Yes**	**No**
Cultural agronomic		
Crop rotation		
Multicroping		
Adjusting planting date		
Improved/competent variety		
Physical and mechanical		
Mulching		
Manual weeding/pruning		
Biological		
Bio pesticides/Trapping		
Biological/Species		

3. Have you ever received extension services on cotton production or crop protection practices in the last one year?

Yes 1 No. 0

4. Where do you sell your cotton?

1. Local retailers

2. Wholesale traders

3. Cooperative

4. Textiles

5. Export

6. Other, specify…………

B. Reasons not to adopt/Barriers, failure to use some of the alternatives to chemical pesticides

Statement of challenges on adoption status	Yes	No
Unavailability of the technology/practices		
lack of awareness of other methods		
being ineffective		
costly to use		

C. PEST MANAGEMENT, PESTICIDE USE AND HANDLING PRACTICES

1. Did you use chemical pesticide (s) in cotton production during the last production season? (IF No, SKIP to 3.)

1. Yes [ ] 0. No [ ]

2. What influenced your decision on the type of pesticide to apply during cotton production?

0. On the first appearance of pests [ ]

1. On calendar basis [ ]

2. Own farming experience [ ]

3. On recommendation by another farmer [ ]

4. On recommendation by pesticide dealer [ ]

5. On first symptom of crop damage [ ]

6. On recommendation by extension agent [ ]

7. Cotton Association ( ),

8. Others, specify …………………….

3. What influenced your decision on the time of application of pesticide during cotton production?

0. On the first appearance of pests [ ] 1. On calendar basis [] 2. Own farming experience [] 3. On recommendation by another farmer [] 4. On recommendation by pesticide dealer [] 5. On first symptom of crop damage [] 6. On recommendation by extension agent [].

7. Other, specify ……………………

4. Reasons for not wearing personal protective gears during pesticide preparation and application

	Perception statements on not taking precaution measures	Yes	No
1	Expansive		
2	Harmless		
3	Lack of knowledge		
4	Not necessary for each case		
5	Uncomfortable		
6	Time-consuming to wear		
7	Unavailable when needed		

5. Risk management /precautionary measures on the prevention of chemical exposures

Perception statements on precaution measures	Yes	No
Avoid drinking while spraying		
Avoid eating while spraying		
Avoid smoking while spraying		
Observe direction of the wind while spraying		
Spray early in the morning		
Spray late in the evening		
Wash hands after spraying		
Take a shower and change clothes after spraying		
Access to training		
Training giving institution for sustainable pest management practices		
Ministry of Agriculture		
Cotton Association/Textile institute		
Environment Authority		
Agricultural research center		
Ministry of Health		
Different NGO's		
Others, specify		

Thank you for your cooperation

Annex II

Level of agreement of respondents' perceptions in a different categories i.e. alternative pest management practices, tolerance/risks and pesticides

Perception Statements		Farm Type				Division/Districts			Total farms (Mean)
		Larg Farm (N=71)		Small Farm (N=191)		Arbamch (N=75)	Amibra (N=89)	Gewan (N=98)	
		N	%	N	%	N	N	N	
Alternatives									
Beneficial organisms /like insect trapping keep pests at low levels	Strongly Disagree	0	0	0	0	0	0	0	3.13
	Disagree	12	16.9	45	23.6	6	20	31	
	Neutral	34	47.9	91	47.6	23	52	50	
	Agree	23	37.4	47	24.6	38	15	17	
	Strongly Agree	2	2.7	8	4.2	8	2	0	
pest scouting is essential for IPM or other sustainable alternatives	Strongly Disagree	0	0	0	0	0	0	0	3.39
	Disagree	1	1.4	40	20.9	0	13	28	
	Neutral	24	33.8	64	33.5	21	26	41	
	Agree	46	64.8	78	40.8	45	50	29	
	Strongly Agree	0	0	9	4.8	9	0	0	
Physical/mechanical means like hand weeding and pruning can reduce rate of pesticide application	Strongly Disagree	0	0	0	0	0	0	0	3..27
	Disagree	9	12.7	43	22.5	8	21	23	
	Neutral	25	35.2	77	40.3	23	33	46	
	Agree	33	46.5	60	31.4	33	31	29	

	Strongly Agree	4	5.6	11	5.8	11	4	0	
Crop rotation reduces risk of crop damage	Strongly Disagree	0	0	0	0	0	0	0	3.47
	Disagree	2	2.8	22	11.5	0	7	17	
	Neutral	22	31.0	84	44.0	18	34	54	
	Agree	41	57.7	75	39.0	47	42	27	
	Strongly Agree	6	8.5	10	5.2	10	6	0	
Adjusting plant date reduces risk of crop damage	Strongly Disagree	0	0	0	0	0	0	0	3.24
	Disagree	5	7.0	62	32.5	0	24	43	
	Neutral	21	29.6	62	32.5	22	22	39	
	Agree	37	52.1	58	30.4	47	35	13	
	Strongly Agree	8	11.3	9	4.7	6	8	3	
Multiple crop can reduce rate of pesticide application	Strongly Disagree	0	0	0	0	0	0	0	3.43
	Disagree	5	7.0	29	15.2	13	7	14	
	Neutral	21	29.6	81	42.4	19	35	48	
	Agree	45	63.1	61	31.9	23	47	36	
	Strongly Agree	0	0	20	10.5	20	0	0	
improved/competent variety can reduce my usage of pesticide	Strongly Disagree	0	0	1	0.5	0	0	1	3.91
	Disagree	0	0	7	3.7	0	2	5	
	Neutral	9	12.7	47	24.6	0	16	40	
	Agree	62	87.3	87	45.5	29	71	49	
	Strongly Agree	0	0	49	25.7	46	0	3	
Use of	Strongly Disagree	0	0	1	0.5	0	0	1	2.96

nontraditional pesticides like bt cotton	Disagree	7	9.9	30	15.7	31	1	5	
	Neutral	58	81.7	138	72.3	27	83	86	
	Agree	6	8.5	21	11.0	16	5	6	
	Strongly Agree	0	0	1	0.5	1	0	0	
Tolerance/Risk									
Low levels of crop pests are acceptable	Strongly Disagree	0	0	1	0.5	0	0	1	3.61
	Disagree	15	21.1	32	16.8	8	0	39	
	Neutral	2	2.8	2	1.0	4	0	0	
	Agree	54	76.1	156	81.7	63	89	58	
	Strongly Agree	0	0	0	0	0	0	0	
It is always not necessary to treat	Strongly Disagree	0	0	0	0	0	0	0	3.02
	Disagree	12	16.9	114	59.7	31	53	42	
	Neutral	2	2.8	2	1.0	3	0	1	
	Agree	57	80.3	75	39.3	41	36	55	
	Strongly Agree	0	0	0	0	0	0	0	
Killing pests is not the major goal	Strongly Disagree	0	0	0	0	0	0	0	3.5
	Disagree	20	28.2	45	23.6	31	25	9	
	Neutral	2	2.8	0	0	2	0	0	
	Agree	49	69.0	146	76.4	42	64	89	
	Strongly Agree	0	0	0	0	0	0	0	
Pesticides									
Chemical control is not	Strongly Disagree	0	0	0	0	0	0	0	3.14

the only reliable method	Disagree	25	35.2	85	44.5	36	29	45	
	Neutral	1	1.4	5	2.6	3	3	0	
	Agree	45	63.4	101	52.9	36	57	53	
	Strongly Agree	0	0	0	0	0	0	0	
Pesticides may not reduce the amount of time	Strongly Disagree	0	0	1	0.5	0	0	1	3.44
	Disagree	19	26.8	51	26.7	29	22	19	
	Neutral	5	7.0	0	0	5	0	0	
	Agree	47	66.2	139	72.8	41	67	78	
	Strongly Agree	0	0	0	0	0	0	0	
Chemical control may not provide independence	Strongly Disagree	0	0	0	0	0	0	0	
	Disagree	16	22.5	70	36.6	29	12	45	3.19
	Neutral	15	21.1	26	13.6	10	31	0	
	Agree	40	56.3	95	49.7	36	46	53	
	Strongly Agree	0	0	0	0	0	0	0	
Dead pests may not show effectiveness	Strongly Disagree	0	0	1	0.5	0	0	1	
	Disagree	20	28.2	66	34.6	12	36	38	3.34
	Neutral	2	2.8	10	5.2	0	11	1	
	Agree	42	59.2	108	56.6	63	40	47	
	Strongly Agree	7	9.9	6	3.1	0	2	11	

Annex III

Farmers level/extent of adoption for ten types of APMP among adopting farmers the total respondents(N=59)

Statements		Frequency (n)	Percent (%)	Mean
Level of adoption for sustainable alternative	Yes(adopters)	59	23	
	No(non-adopters)	203	77	
How often you rotate		204	78	
	Never	5	2	
	Seldom	30	11	
	Frequently	19	7	
	Very frequently	4	2	
	Always	0	0	2.38
Intercropping	Never	1	0	
	Seldom	28	11	
	Frequently	29	11	
	Very frequently	0	0	
	Always	0	0	2.48
Mulching	Never	35	13	
	Seldom	11	4	
	Frequently	9	3	
	Very frequently	0	0	
	Always	0	0	1.53

Use of improved crop/competitive/strong varieties	Never	9	3	
	Seldom	47	18	
	Frequently	1	0	
	Very frequently	0	0	
	Always	0	0	1.86
Adjusting planting date	Never	15	6	
	Seldom	26	10	
	Frequently	17	6	
	Very frequently	0	0	
	Always	0	0	2.03
Manual weeding/Pruning	Never	3	1	
	Seldom	5	2	
	Frequently	46	18	
	Very frequently	3	1	
	Always	1	0	2.9
Crop residue destruction	Never	1	0	
	Seldom	15	6	
	Frequently	39	15	
	Very frequently	2	1	
	Always	0	0	2.74
Multi/Mixed cropping	Never	3	1	
	Seldom	31	12	2.26

	Frequently	23	9	
	Very frequently	0	0	
	Always	0	0	
Use of traps	Never	6	2	
	Seldom	30	11	
	Frequently	19	7	
	Very frequently	2	1	
	Always	0	0	2.3
biological species	Never	0	0	
	Seldom	0	0	
	Frequently	0	0	
	Very frequently	0	0	
	Always	0	0	-

Annex IV

Reason/Familiarity to adopt APMP among adopting farmers(N=59)

Familiarity statements		Frequency (n)	Percentage (%)	Mean
I find economic advantage in using IPM in my cotton production	Strongly Disagree	0	0	
	Disagree	1	0.01	
	Agree	4	2	
	Strongly Agree	47	18	3.88
I prefer IPM based on personal safety reasons	Strongly Disagree	0	0	
	Disagree	0	0	
	Agree	24	9	
	Strongly Agree	28	11	3.54
I like IPM because it does not require too much time	Strongly Disagree	5	2	
	Disagree	10	4	
	Agree	37	14	
	Strongly Agree	0	0	2.62
I prefer IPM practices to protect the environment	Strongly Disagree	0	0	
	Disagree	6	2	
	Agree	35	13	
	Strongly Agree	11	4	3.1