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Adoption of Modern Agricultural Technologies in Urban Agriculture:

A Case Study in Mekelle City-Vegetable Growers

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DECLARATION

I declare that this thesis is my original work and has not been presented for a degree in any university and all the sources of materials used for the thesis are properly acknowledged.

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CERTIFICATION

As the *Thesis* Research advisor, I hereby certify that I have read and evaluated this thesis prepared under my guidance by **Haile G/Mariam Tesfu** entitled "**Adoption of Agricultural Technology in Urban Agriculture: A case Study in Mekelle City-vegetable growers.**"

I recommend that it be submitted as fulfilling the *Thesis* requirement.

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DEDICATION

I dedicate this thesis text to the Office of Auditor General Tigray Region for its sponsorship of the whole MSc study, treated me with patience to complete my study, and to all respected my friends for their unreserved support in the victory of my thesis.

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Abstract

Urban agriculture is an important strategy in supplying for every growing urban population affordable food and adding to their nutrients. Moreover, producing vegetable plays a significant role in contributing to the welfare of particularly poor urban residents. Vegetables are the main source of nutrients and their socio-economic importance is quite clear to the urban citizens. Consequently, production and productivity of vegetable in the urban areas should be improved. This improvement will solely be complete if modern agricultural technologies are utilized; among the most modern technologies fertilizer and pesticide take priority because of their contribution to soil fertility and hence output. In this study, the determinants of the likelihood of fertilizer and pesticide adoption decision, the intensity of use of fertilizer and volume of use of pesticide on vegetable production and whether or not income difference has come between the adopters and non-adopters of the growers in Mekelle city(the study area) were investigated. The heckman two-satage model, and OLS, which consists of a sample of 204 households, was used in the analysis. The study used both primary and secondary data for analysis. Probit regression model was employed to spot factors that determine adoption decision of the agricultural input chemical technologies like fertilizer and pesticide and heckman two-stage model was used to check financial gain difference between the adopters and non-adopters regarding to those technology adoptions. Additionally, the intensity of use of fertilizer and volume use of pesticide were investigated by employing the OLS (linear regression) model. Therefore, this study intends not solely to contribute one thing in filling the gap of data on urban agriculture by taking one part of urban agriculture that is technology adoption within vegetable production, but also aims to attract attention to the comparatively neglected area of urban agriculture. To this end, the study tried to spot the determinants that affected technology adoption decision and their intensity/volume of use in the city vegetable growers. It also tried to examine how technology adoption led to higher financial gain of the growers. Based on the result of this study, the factors that affect the likelihood of fertilizer, pesticide, and joint adoption, the intensity of use of fertilizer and volume of use of pesticide, and the income difference of the adopter and non-adopters were explained like age of household head, educational level of the household head, sex of the household head, household family size, farmer's farming experience on vegetable cultivation, cost of fertilizer, farmer's perception on fertilizer, soil fertility, closeness of farm land to homesteads, nearness of market to farm land, extension support, access to credit, farm size, sufficiency of irrigation water, off-farm activities, purpose of farming, total household income, cost of pesticide, and farmer's attitude towards pesticide. This result has vital implication for the formulation of policies and programs targeted to promotion of chemical fertilizer and pesticide use in urban vegetable production mainly in the study area (Mekelle city) and other cities with similar ecological systems.

Key words: Farm technology, adoption, intensity, heckman, Least Ordinary Square, Mekelle

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LIST OF ABBREVIATIONS

ADEMEO	Agricultural Development, Environmental protection and Mining and Energy office of Mekelle City
BoARD	Bureau of Agricultural and Rural Development
CC	Contingency Coefficient
CSA	Central Statistical Agency(Ethiopia)
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FEPA	Environmental Protection Agency
FTA	Fertilizer Technology Adoption
GDP	Gross Domestic Product
IARD	integrated agricultural research for development
MC	Mekelle City
MoFED	Ministry of Finance and Economic Development
OLS	Ordinary Least Squares
PTA	Pesticide Technology Adoption
PTD	participatory technology development
UA	Urban Agriculture
UN	United Nation
UNDP	United Nations Development Program
VIF	Variance Inflation Factors
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Many of the countries, which register fast urban growth, are least-developed countries. However, these countries aren't capable enough to provide sufficient food demanded by the expanding urban population and filled the food gap via import from rural areas (Tewodros, 2007).

According to Food and Agriculture Organization of the United Nations (FAO, 2001), Urban Agriculture (UA) contributes to urban food security through increased food availability, price, and output supply stability and, to some extent, accessibility. Moreover, as explained by Catherine (2000), the social and environmental benefits of UA are urgently required by cities as the world faces fast process of urbanization-the largest migration in human history.

It also increases food diversity, improves the standard of urban diets through diversification, by adding farming and animal products to the premise of staple food. Urban Agriculture contributes to poverty alleviation both through reduction of food expenditures and through an increase of financial gain, and most significantly by creating employment. As an example, Urban agriculture employs 800 million urban residents worldwide (UNDP, 1996). Moreover, UA creates green zone with in and around the city and modify local micro climate, and recycle solid and liquid wastes. Different advantages of UA includes access to consumer markets, reduction in post-harvest losses, less want for packaging, storage and transportation of food, proximity to services, including waste water treatment facility, etc.(FAO, 2001).

Ethiopia has a variety of vegetable crops grown in different agro ecological zones produced through commercial as well as small farmers each as a source of financial gain as well as food. However, the sort is restricted to few crops and production is concentrated to some pocket areas. In spite of this, the production of vegetables varies from cultivating a few plants in the backyards for home consumption up to a large-scale production for domestic and export markets

(Dawit, 2004). According to the CSA (2008) 453,608.8 ha of land is under vegetable in Ethiopia, in general. Accordingly the study (CSA, 2008), estimated that an annual production of 18,124,613.5 quintal was estimated from vegetable by the same year.

In a country like Ethiopia, where the amount, timing and distribution of rain fall is irregular, use of irrigation would significantly improved and raise the level of production. However, irrigation is not extensive in Tigray region. In the rural area of the region, crop lands that are literally irrigated were solely 19.1 thousand hectare and this accounted for 3.4% of the total crop land areas. Out of the whole irrigated cropland areas within the region 72.2% were under cereals, 10.3% under pulses, 9.3% under fruits 3.6% under stimulant crops and 4.3% under vegetables (CSA, 2008). On a similar year, the census data indicated that irrigated crop land area was relatively highest in south Tigray zone (74.4%) followed by central Tigray zone (16.6%). This indicated that irrigation practice in the region differs from zone to zone based on the natural wealth endowment. Even though, Tigray Regional State has an abundance production potential and market access even within the region it had never been reaped the chance (CSA, 2008).

Unfortunately, there is no documented data about urban agriculture in the region and the urban agricultural practice does not supported by appropriate policy (Audit report, 2008; Mohammed, 2002).

Mekelle city (MC), where this study focuses, has potential market demand and endowments in terms of capacity to grow different vegetable crops and others. The high demand/market/of vegetables encourages production of horticultural crops particularly vegetables. On top of this, the existence of stream irrigation supplements the erratic nature of rain.

Major types of vegetable crops currently growing in the city are *onion, potato, tomato, green-pepper, salad, Lettuce, cabbage, Beet-root, "kusta,"* etc. The production of vegetable crops in the *city* is mainly for market; extremely random and fragmented.

Although vegetable crops are essentials for health and economy, the quantity of production is small and mode of production is traditional in the city.

1.2. Statement of the Problem

Urban agriculture is a traditional practice in Ethiopia in general, and the urban-based population is used to keep cattle, sheep, and chickens, or growing rain-fed crops and vegetables, on the plots adjacent to their houses (Gittleman, 2009). Additionally to its advantages for the production of foods from vegetables, crops and rearing animals, urban agriculture has socio-economic advantages.

Despite of its advantageous nature, urban agriculture in the study area (MC) has included a lot of factors that may have effect on adoption of agricultural technologies in vegetable growers. Low production and productivity, which are mainly associated with poor adoption of modern technologies, were among the major problems.

Vegetable production within Mekelle city is mainly with the application of stream irrigation, ponds, shallow well, and rain fall. There are production and productivity problems challenging vegetable development within the city. These are input supply, pest and disease, low productivity, production seasonality (BoARD, 2007). This, thus, demands a holistic study of the factors affecting adoption of agricultural technologies in Urban Agriculture (The Case of Fertilizer and Pesticide in Vegetable producers). A number of things associated with social, economic, and institutional factors influence adoption of agricultural technologies. Therefore, information on factors that affect adoption of agricultural technologies is essential for the design of any strategy or policy that has intervention objective.

Although vegetables are economically vital commodities, there has no study made on vegetables production to spot the key constraints and potentials on the adoption of agricultural technologies particularly on fertilizer and pesticide within the city. It is essential that vegetable growing should support by adoption of technologies like fertilizer and pesticide for enhancing production and productivity.

Adoption of chemical fertilizer and pesticide are supposed to be as a problem within the city in general, vegetable producers in particular. Investigation of adoption of modern agricultural technologies particularly on chemical Fertilizer and Pesticide in vegetable growing is influencing with social, economic, and institutional factors taking in to consideration the product and location specificity has, therefore, be used to identify the restricting factors. Though, there are some researches that have conducted based on different aspects of UA in MC(like Urban and Peri-Urban Agriculture: An Important Form of Land Use, Employment Opportunity and Food Supply in Mekelle City and Enderta Woreda, conducted by Gebremedhin and Bihon, 2009) none of them has dealt on technology adoption especially on vegetable growing fields. In contrast to the previous completely different works, this analysis has conducted to deal with the true of the factors that have an effect on adoption of modern agricultural technologies, to state the intensity of the adoption, and to check whether or not technology adoption brings to higher financial gain of the adopters inside the vegetable growers of the city with their counterparts of non-adopters and come up with potential recommendations.

1.3. Objectives of the Study

1.3.1. General Objectives:

The objective of this study is to examine the social, economic, and institutional factors that influence adoption of modern agricultural technologies, intensity of use of the technologies and to see its impact on income of the actors in Mekelle city.

1.3.2. Specific Objectives:

The specific objectives of the study embrace the following:

1. To identify factors that have an effect on adoption of agricultural technologies particularly of chemical *fertilizer* and *pesticide* within vegetable growers in Mekelle city,
2. To analyze the intensity of use of the modern agricultural technologies (fertilizer and pesticide) in vegetable growers in Mekelle city,
3. To assess if the adoption of the technologies(fertilizers and pesticides) leads to higher financial gain of the vegetable growers,

1.4. Research Questions

i. What are the foremost socio-economic and institutional factors that have an effect on adoption of modern agricultural technologies?

ii. What is the intensity of use of the modern agricultural technologies (the chemicals) within the vegetable growers inside of the city?

iii. Does adoption of the technologies (the chemicals) bring higher financial gain of the vegetable growers in comparison to their counterparts/non-adopters/?

1.5. Significance of the study

The main purpose of this *study* is educational *purpose*. As a student I actually have to pass the communicating during this process, so I shall have to be required to learn enough regarding analysis ways and techniques to accumulate the expected knowledge of the subject to write different assignments of acceptable standard in my future career independently.

Besides, this study may contribute the subsequent basic points:

- √ This study can contribute to the stock of information regarding the city's urban agriculture.
- √ The potential beneficiary of the results of this study, mainly, would be growers, administrators, and policy makers; governmental and non-governmental organization, who need to introduce interventions in Adoption of Agricultural Technologies in urban agriculture, vegetable growing particularly.
- √ Furthermore, this study may well be used as source material for additional study. The added knowledge on which factors that have the greatest influence on adoption of agricultural technologies in urban agriculture and helps administrators make more informed decisions on how to promote urban agriculture normally, vegetable production particularly.
- √ Another important benefit from the analysis is provision of an evidence of the current intensity of use these technologies utilized by vegetable growing farmers. Moreover, since adoption of agricultural technologies in urban agriculture involves a variety of practices that are specific to individual crops, measuring its adoption on vegetable crops may provide a strong case for increasing investment in various urban agricultural researches.

1.6. Scope and Limitation of the Study

Geographically, the study has restricted to Mekelle City, which is the capital of Tigrai region. During this analysis, factors influencing adoption of agricultural technologies with relevancy chemical fertilizer and pesticide by vegetable growers of the city were the subject of the study. The study tried to assess that factors adoption of the technology, the intensity of use of the technology within the city and to look at whether or not technology adoption led to higher financial gain to vegetable growers in Mekelle city. And here specific issues connected with land use, socio-economic condition of home farms, and therefore the practice of vegetable production with reference to the adoption of chemicals like fertilizer and pesticide; and opportunities of using those technologies in enhancing production have assessed. However, since this study is limited to technology adoption, it cannot provide detailed information about other related problems related to urban agriculture of the city. Lack of adequate historical data is also another problem in this study. The available information also varies in many ways from year to year. Urban agriculture was in practice for many years in the city but it is difficult to get statistical information from the responsible bodies. In addition to this local problem, lack of related literature about agricultural technology adoption within urban agriculture in general and within vegetable producers in particular is one of the significant limitations for this study. Therefore, the study has undertaken to fulfill its objectives inside the mentioned constraints.

1.7. Thesis Structure

The rest of this thesis is organized in six sections. Section two, dealt with review of literature that includes definitions of concepts of AU, vegetable growing, agricultural technology, and therefore the want for technology adoption within the vegetable growing farmers. Section three has presented methodology with a brief description of the study area, sampling method, and methods of data analysis. Obtained results are discussed in more detail in section four. Section five has presented conclusions and policy implications.

CHAPTER TWO

LITERATURE REVIEW

2. Theoretical Literature

2.1. Definition and concept of Agriculture

Agriculture is formed from two Greek words known as 'ager' meaning 'field' and 'cultura' meaning 'cultivation'; it literally means "field cultivation" Mark, (2011).

Agriculture, also called farming or husbandry, is the cultivation of animals, plants, fungi, and other life forms for food, fiber, bio-fuel, medicinal and other products used to sustain and enhance human life(ibid)

The major agricultural products can be broadly grouped into foods, fibers, fuels, and raw materials. Specific foods include cereals (grains), vegetables, fruits, oils, meats, and spices. Fibers include cotton, wool, hemp, silk, and flax. Raw materials include lumber and bamboo. Other useful materials are produced by plants, such as resins, dyes, drugs, perfumes, bio-fuels and ornamental products such as cut flowers and nursery plants. http://en.wikipedia.org/wiki/Agriculture.

Agricultural practices such as irrigation, crop rotation, application of fertilizers and pesticides, and the domestication of livestock were developed long ago, but have made great progress in the past century. The history of agriculture has played a major role in human history, as agricultural progress has been a crucial factor in worldwide socio-economic change. Division of labor in agricultural societies made commonplace specializations rarely seen in hunter-gatherer cultures, which allowed the growth of towns and cities, and the complex societies we call civilizations. When farmers became capable of producing food beyond the needs of their own families, others in their society were free to devote themselves to projects other than food acquisition. Historians and anthropologists have long argued that the development of agriculture made civilization possible (Jared Diamond, 2012).

Agriculture is the key development that led to the increase of civilization, with the agriculture of domesticated animals and plants (i.e. crops) creating food surpluses that enabled the event of additional densely inhabited and stratified societies(Singh, 2001). Agriculture encompasses a large kind of specialties. Cultivation of crops on tillable land and the pastoral herding of livestock on rangeland remain at the foundation of agriculture.

Urban agriculture is one of the important sub sectors that need great focus because it served as a significant input in the resource ways of urban households particularly within the developing countries (FAO, 2008).

2.2. Definition and concept of Urban Agriculture

Urban agriculture may be a recent development as compared to rural farming. Different authors outlined urban agriculture in varied ways in which on the idea of location or time of agricultural activities. For Bryld, (2003), any agricultural activity that's practiced in cities is taken into account as urban agriculture.

Deelstra and Girardet (2004), additionally place urban agriculture as any agricultural production like farming, horticulture, floriculture, forestry, fishery, poultry, and livestock primarily publicly open areas within or outer part of cities. UNDP (1996), thought urban agriculture as one kind of city industry wherever its produces are supplied to market to satisfy daily demands of urban consumers.

Thus, examining urban agricultural activities is crucial to know urban agriculture and determine its distinctive options. Mireri et al. (2006), further defined features of urban agriculture as follows: Any kind of crop or livestock production and agro-foresty or fuel wood production that is practiced within and border of cities is urban agriculture. Mireri et al. (2006) added, in urban agriculture the choice of what to produce and how to produce is determined by the culture, tradition, markets, water supply, rainfall, climate, exposure to sun, soil condition, farm land size, and distance to home. Family and individual resources, land accessibility, and site are also crucial determinants of the kind of urban agriculture practiced.

In Africa, urban cultivation has become a permanent part of the landscape. within the beginning of the 1980s, a simple 10–25% of the urban population in Africa was engaged in urban agriculture while up to 70% of the urban population in Africa, and up to 60% in Asia, have become urban cultivators in the 1990s (Rogerson, 1997). Despite the fact that it is difficult to search out recent information, which states this scenario of world's urban agriculture, it is well-known that with the increasing nature of urban population and quick urbanization, the demand aspect of urban farming and its socio-economic importance are also increasing.

Urban agriculture isn't simply vegetable production or husbandry. In several case studies, urban and peri-urban agriculture is represented as a system of various agricultural activities, well integrated into and a part of a additional or less electrical circuit of energy flows and production and consumption pattern(Drescher and Iaquinta 1999, FAO 2000).

2.3. Importance of Urban Agriculture

"Real agriculture" was thought to take place within the rural sector solely. Therefore, the rural and peri-urban sectors were foretold to feed the urban population. In reality, this duty has failed in many countries because of an absence of infrastructure and also the lack of buying power of the urban poor (Drescher and Iaquinta, 1999).

Drescher and Iaquinta, (1999), added that Urban farms will and do play a very important role in urban society food system. Despite the very fact that, urban farms are unlikely to satisfy all of a municipality's produce needs, they will produce a good and meaningful quantity and provide to the urban consumers (ibid).

The benefits of UA embrace potential to supply low-cost, fresh and nutritious food; less would like for packaging, storage and transportation of food; reduces the cost of waste assortment, treatment and disposal in addition as open public area maintenance and environmental protection; potential to form agricultural jobs and incomes and; non-market access to food for poor consumers (FAO 2000).

Urban agriculture is one source of supply in urban food systems and only one of several food security choices for households; equally, it's one in every of many tools for creating productive use of urban open areas, treating and/or recovering urban solid and liquid wastes, saving or generating financial gain and employment, and managing freshwater resources more effectively (Anderson, 1988).

Urban farming may be a decent supply of financial gain for the urban poor, if it is particularly practiced as a proper sector. Some late studies assert that an estimated 800 million people are engaged in UA worldwide; of these, 200 million are market producers, employing 150 million people full-time (Smit et al. 1996).

In Africa, 40% of urban dwellers were said to be engaged in some kind of agricultural activity and this percentage rises to 50% in Latin American countries (Ruel et al., 1998). The study of Denninger et al. (1998), estimates that just about 25 out of the 65 million people living in urban areas state of Eritrea, Ethiopia, Kenya, Tanzania, Uganda and Zambia acquire part of their food from UA which, by 2020, a minimum of 35-40 million urban residents can rely on UA to feed themselves. Furthermore urban agriculture additionally provides self facilitate food production for the poor whose lack of food isn't simply a drag of provide however of economic access. Self facilitate food production either provides food itself for poor families or financial gain that to buy food. Besides to this, urban agriculture will furnish a big contribution to the poorest of the poor, for whom little amounts of food will create a vital distinction (Sacks and Silk, 1987).

In addition, urban agriculture offers many advantages to the cities from an ecological point of view in terms of resource conservation and waste exercise. Urban agriculture is that the largest and most effective tool on the market to rework urban wastes into food and jobs, with by-products of an improved living surroundings, higher public health, energy savings, natural resources savings and urban management cost reduction (Keboneilwe & Hovorka, 2001).

Urban Agriculture presents shorter distance from the producer to the consumer that creates fewer desires of selling, transportation, and packing those products, which are grown at distance, providing a cost advantage over rural agriculture (Keboneilwe & Hovorka, 2001).

Urban agriculture additionally contributes to a community's nutritional self-reliance, reducing hunger and deficiency disease in urbanizing areas around the world. At constant time, people's expectations of a food's freshness still increase.
The World Bank (UNDP, 1996) has shown that a majority of adults and children living in low-income urban areas have diseases that limit their capacity to learn

and work. This case will be improved if the citizens are engaged in urban farming, which is able to decrease deficiency disease and increase the amount of food intake. Resources freed by the production of urban cultivation, for instance, can be used to balance the family diet by buying other forms of food, e.g., fish, fruit, and vegetables. Urban poor are generally more dependent on cash income to buy food. Daily dietary intakes, therefore, vary in line with the day's financial gain and market values. Consequently, a stable intake of self-grown produce can cut back the citizens' dependence on their unsteady salaries and improve their nutrition (Smith, 1996; UNDP, 1996).

Urban Agriculture encompasses a large kind of specialties. Horticulture is onein every of the various specialties stay wide practiced sub-sector in UA. Vegetables are primarily produced by horticulture and only for human nutrition. A group of crops known as "vegetables" consists of more than 200 plant species all over the world (Sacks and Silk, 1987).

2.4. Definition and Concept of Vegetables

The term vegetable is used to describe the caring edible shoot, leaves, fruits and root of plants and spices that are consumed whole or in part, raw or cooked as a supplement to starchy foods and meat(Williams et al, 1991).

Vegetables are also described as those plants, which are consumed in relatively small quantities as a side dish with the staple food. However, Vegetables are important food varieties within the human diet because they provide nutrients like vitamins and minerals and also the bulk of roughage the body desires and which are usually lacking in most traditional staple foods(Williams et al, 1991).

2.4.1. Classification of Vegetables

Distinguishing vegetables in line with the part consumed is a method of classifying vegetables. According to the part consumed (character) vegetables can be described as follows:

- *Leafy vegetables:* the leaves and juicy young shoots are picked for consumption. Examples are, lettuce, cabbage, bitter leaf, water leaf, jews mallow and fluted pumpkin,

- *Fruit vegetables:* this contains of young, immature unripe fruits or mature ripe fruits of plants grown as vegetables. Examples are tomato, pumpkin, water melon and chilli pepper,
- *Seed vegetables:* this group is important for the seed produced. Examples are Egusi melon and Ito melon,
- *Root vegetables*: such as sweet potato, carrot, and radish are grouped in this area, and
- *Spices*: important for their flavor and color in foods such as chilli pepper, onion, garlic, and basil.

2.4.2. Principles and Practice of Vegetable productions

According to Sacks and Silk, (1987), there are some principles needed in the production of vegetable crops, which are very important and well known to the producers. These principles are:

1. Production of vegetables does not involve a long- time investment as does in the woods of citrus, mango, or cashew,
2. Vegetable growers/farmers don't seem to be sure to produce the same crop every year like his counterparts, who grow fruit crops,
3. Vegetable growing lacks the stability which is systematically developed over a period of years like an orchard thus, getting into vegetable production is a fast process and getting out may even be faster,
4. Vegetables can be grown by people with limited experience. Only skillful farmers keep going their vegetable production,
5. The land for production of vegetable crops is flexible and adjustable. It is much easier for vegetable growers/farmers to vary production from one crop to another than for fruit crop grower,
6. Cooperative efforts and organizations are somewhat more difficult with vegetable crop producers than fruit growers are. Vegetable/grower/farmers have no long period for making plans. Vegetable production is seasonal, and
7. Vegetable production requires more intensive production management per unit area and time.

Therefore, having those advantages vegetable growing makes more beneficiaries to the urban growers as well as urban economy.

2.5. Socio-Economic importance of vegetable

As urbanization increases, the need for sufficient food also increases. The opportunity to grow and/or acquire food produced locally, therefore, becomes a critical component in surviving in the city. Thus, producing vegetable plays a significant role in contributing to the welfare of particularly poor urban residents (Maxwell, 1995).

It is well known that cultivating vegetable crops is the most common agricultural activity by the urban crop producers. Vegetables are important for our well being because of the following (Smith and Pablo, 2007):

1. Vegetables are rich sources of vitamins and other essential nutrients: Vegetables play an important role in human diet and are essential for balanced diet and maintenance of good health. The vegetables are rich sources of protein (Moringa and peas), minerals like calcium (tomato, spinach, and peas), Phosphorus (tomato, cucumber), Iron (Spinach, peas, tomato, and bitter gourd), Iodine (Okra, Summer squash) Vitamins like Vitamin A (Leafy vegetables, pumpkin), Vitamin B (Peas, Spinach, tomato), Vitamin C (Moringa, chilli, tomato,) and Vitamin K (Leafy vegetables),
2. Vegetables have lots of protective compounds like Cheratin in bitter gourd is effective against diabetes and most of the leafy vegetables and pumpkin are the rich source of beta carotene,
3. Vegetables gave more yield than other traditional crops like wheat and rice. The yield of wheat is about 50-55 qtls per hectare and in vegetables like tomato it is about 250 qtl per hectare. Thus they provide higher quantity of food per unit area,
4. Vegetables gave more farm income than other crops,
5. The cropping intensity in vegetable growing is very high as compared to others. Normally 3-4 vegetable crops can be raised in one year.
6. Vegetables have high export potential,
7. The aesthetic worth of vegetables is quite higher than other field crops, and
8. The vegetables have given a boon to processing industry as they can be processed to form diverse compounds like sauces, chutneys, pickles etc.

Vegetables are part of the daily diets in the form of soups and sauces accompanied by carbohydrate staples (Smith and Pablo, 2007).

Vegetables are thought to be an important part of a healthy diet and if sufficiently consumed in daily amounts, might facilitate in the prevention of major diseases like coronary heart diseases and cancers (Renaud *et al*., 1995).

Low vegetable intake is identified as a major contributor to mortality and that adequate consumption could help prevent major chronic non-communicable diseases. WHO, (1990) recommended that, a minimum of 400g/day of vegetable/fruit is required by an individual; however, the consumption is very low in sub-Saharan Africa (27-114kg/capita/year). This is far below the WHO/FAO recommended level of 146kg/capita/year (WHO/FAO, 2004).

Apart from improvement within the quality of the diets and health, the production and marketing of vegetables provides employment to many people especially in the dry season (Obuobie *et al.,* 2006). Therefore, as high amount of vegetables are needed, it should be supported by appropriate agricultural technologies so that enhance output.

Vegetable crops are important for almost every household in any urban as a producer and as consumer. In line with Dittoh (1992), Vegetable crops not only improve the nutritional quality of diets, the production of vegetables under irrigation and their marketing provides many people with employment in the dry season as full-timer and as part-timer.

Surveys carried out in Cameroon and Uganda by Schippers (2000); give proof that vegetables offer a significant opportunity for the poorest individuals to earn a living, as producers and/or traders, without requiring large capital investments.

Schippers(2000) added, vegetables are important items for poor households because their prices are relatively affordable when compared to other food items.

Another research conducted by UNDP (1996), has shown that a majority of adults and children living in low-income urban areas have diseases that limit their capacity to learn and work. This situation can be improved if the citizens are engaged in urban farming specifically in vegetable growing, which will decrease deficiency disease(malnutrition) and increase the quantity of food intake. Urban poor are usually more dependent on cash income to buy food. Daily dietary intakes, therefore, vary in line with the day's income and market price. Consequently, a stable intake of self-grown produce will reduce the residence' dependence on their unsteady salaries and improve their nutrition (Smith, 1996; UNDP, 1996).

As vegetables are cash crop products, it can be a good source of income for the urban poor, if it is especially practiced as a formal sector. Especially, if growing has supported by technologies, vegetables can became good and sufficient source of income for the urban citizens; for the growers as well as for the consumers (Dittoh, 1992).

RUAF (2007), reported that the poor households in developing countries spend 50-70 % of their income to purchase foods; hence, it appreciated the benefits of self-growing crops and/or participating in other forms of urban agriculture by the urban poor. The report also confirmed "in Addis Ababa, Ethiopia, above-normal profits are earned by even the smallest-scale backyard producers with very low capital" (Staal 1997; RUAF 2007)

2.6. Vegetable production in Ethiopia

As in alternative urban areas of the world happen, vegetable is produced in Ethiopian urban areas. In all cities of the nation, different types of vegetables for different purpose (either for commercial or direct consumption), are producing.

Vegetable producers living near to urban centers largely practice vegetable farming. As most vegetables are not commonly practiced by the rural private peasant growers, the small volume of production recorded as well evidenced by the results of agricultural sample survey, 2012. vol. I.

Vegetables took up about 1.43 % of the area under all crops at national level(urban and rural). However, Of the total estimated area under vegetables, the lion share which is about 70.89% and 18.07% was under Red peppers and Ethiopian Cabbage, respectively(ibid). Production of vegetables contribute 2.95% of the total crops production, conversely, of the total production of vegetables, the above mentioned crops have the lions share, i.e. about 37.14% and 43.53%, in that order all over the country. However, the nation doesn't have policy regarding urban agriculture (Performance Audit report, 2008;).

2.7. Vegetable Production in Mekelle

Vegetable growing is also practiced in Mekelle city (MC) mainly for market purposes. From the seven administrative sub-cities of Mekelle, the five sub-cities, namely; 'Quiha', 'Semen', 'Hadnet', 'Hawelty', and 'Ayder' sub-cities are the most vegetable growing sites (ADEMEO, 2013). The city has river and other small streams that supply water for irrigation to the vegetable growing farmers. In addition, there is a mini-dum around "Kelamino", which serves the growers for irrigation. Therefore, these water accesses enable the city to get different vegetables in fresh and affordable prices in important quantity (Own physical observation, 2014).

Though there is no well-documented proof that indicates what amount for each type of vegetables in every season are supplying to the city, it is believed that all the vegetables produced in the city is marketed and consumed in the local market. As the data found from Agricultural development, Environmental protection and Mining and Energy office of Mekelle City (AEMEO) indicated, important quantity of vegetable are producing in the city in general. However, it does not mean that it is enough produce to satisfy the demand for the local market. Unknown, but significant amount of different types of vegetable are importing from surrounding weredas, other states of the country, and neighboring country (Sudan) to satisfy the local market. Therefore, this situation indicates urban agriculture, especially vegetable growing demanding modern agricultural inputs (Own observation, 2014).

2.8. Definition and concept of agricultural technology

Here within the contexts of this paper, we have seen only two chemical agricultural technologies, namely fertilizer and pesticide, which they are applying in the whole world (developing and developed) as they are crucial for the enhancement of agricultural output. These two chemicals are necessary to the agricultural sector wherever they play a significant role in helping technological transformation, yield increase, and growth (Singh, 2001).

2.8.1. Definition and Concept of chemical fertilizer technology (CFT)

Nutrients removed from the soil must be replenished, otherwise the soil becomes exhausted, and crops can suffer and eventually fail. Sustainable plant production needs the replacement of nutrients, which are taken out through the crops, and fertilizer is important to attain the amount of agricultural production required for the rapidly growing population (Gershuny and Smillie, 1999).

Fertilizer is a material that furnishes one or more of the chemical elements necessary for the proper development and growth of plants. The most important fertilizers are fertilizer products (also called chemical or inorganic fertilizers), organic manures, and plant residues (Hart and McNeilan, 2000).

Organic manures not only add the essential nutrients to the soil but they also improve the soil texture and structure. They also increase the water holding capability and aeration of soil. However, the organic manures are needed in bulk as they have little proportion of the nutrients and these nutrients are released slowly. Therefore, the chemical fertilizers are preferred as they're needed in small quantity and release the nutrients quickly (Jahns, 2005).

A chemical fertilizer is a material produced by industrial process with the specific purpose of being used as a fertilizer. They *are salts and Salts are chemical compounds that contain one positively charged ion (cation) bonded to one negatively charged ion (anion). When a salt is placed into water, the two ions separate and dissolve. An example of a fertilizer salt is calcium nitrate, which contains one calcium cation and a nitrate anion* (Hart and McNeilan, 2000).

Fertilizer is one of the most entrenched and widely used agricultural inputs so far as the Ethiopian government is concerned. It has also been a product, which has been receiving continuous government support for its promotion, and market development, as it is directly contributing to food production increase (ibid).

According to the 2001/2002 agricultural sample enumeration results, cited by Federal Environmental protection Authority (FEPA, 2004), fertilizers were applied on only 4,055.629 hectares (39.53%) of the total cultivated cropland area of the country(rural and urban areas). Of this, the total fertilized cropland area the share of natural fertilizer applied area was found to be 1,549,968 hectares (38%), while the contribution of chemical fertilizer applied croplands area was 2,505,661 hectares (62%) of the total fertilizer cropland area at country level. Moreover, of the total fertilized cropland area, the share of rural private agricultural holdings was found to be 3,755,178 hectares (93%). The proportion of the total fertilized cropland areas for urban and commercial farms was 62,755 hectares (1.55%) and 237,697 hectares (5.86%) in that order.

Though the very importance of it, the level of fertilizer consumption is still very low compared to many other countries which itself gives an idea of the potential market for fertilizers in the country. Per hectare consumption in the country in 2011 was 43. kg compared with 560 kg in Netherlands, 407 kg in Japan, 314 kg in south korea, 216 kg in china, and 101 kg in Pakistan, 70 kg in Zimbabwe and 48 kg Kenya(Singh, 2001; Teame, 2011). Further, there are sharp regional variations in consumption of fertilizer. Fertilizer consumption in Ethiopia is highly diversified and very low in terms of per hectare use as compared to developed countries. However, fertilizers have played a key role in improving the food grain production in the country. If we look at the past 40 years(after 1966 E.C) of the history of fertilizer use in the country, we find a considerable increase in the consumption of fertilizers(Teame, 2011). According to Crawford et al. 2006; Jayne et al. 2003, cited by David et al. 2011, when measured in terms of quantity imported, fertilizer use in Ethiopia has increased from 250,000 tons in 1995 to 550,000 tons in 2011. This growth of total fertilizer consumption was more rapid than the average for Sub-Saharan Africa over the same period. Fertilizers will continue to play a crucial role in agriculture into foreseeable future. Because the productivity of land per hectare corresponds to the fertilizer consumption. In line with this, a study conducted by Mulat et al (1997) indicated that one ton of fertilizer can yield *3-7 tons* of additional grain in high potential areas.

In general, the role of fertilizer in improving the declining nutritional status and productivity of Ethiopia's soil is widely recognized. Why the massive, state-led policy and program formulated to boost the use of fertilizer has only brought a marginal improvement in its use (especially in terms of use per hectare of farm land) and disregarded impact in terms of improving cereal productivity and food security(Teame, 2011).

There is widely held view that poverty reduction in Ethiopia is impossible without significant growth in crop yields for major staples. One of the best strategic tools is using fertilizers (David et al. 2011).

The use of fertilizers is also an important component of commercial vegetable production. Fertilizers replace nutrients removed during harvest and allow growers to manage crop nutrition for maximum yield (Riofrio, 1992).

Fertilizers whether they be chemical or those organic (i.e. manure) are applied to improve the health of garden vegetables by providing nutrients, which are not adequately supplied by the soil. Considering this reality, it is necessary to continue to use the fertilizer all over the country(ibid).

Though, agriculture production in the world is increasing, it is realized that it is decreasing by different reasons. For example, the biological factors cause a loss of about 35 per cent of world agricultural outputs Singh, (2001). Therefore, applying preventing technologies (such as pesticides) are crucial at least to minimize such loss of agricultural outputs. Here in the next sub-topic, we will see the important disease control chemical technology, namely, Pesticides.

2.8.2. Definition and Concept of pesticides

Pesticides are any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mites and other animals, unwanted plants (weeds), fungi, or micro-organisms like bacteria and viruses. Although usually misunderstood to refer only to insecticides, the term "pesticide" also applies to herbicides, fungicides, and various other substances used to control pests or growth of plants as approved by the relevant authority for application to crops or the growth of plants (Singh, 2001).

According to Singh (2001), Pesticides are a group of chlorine agents used in plant protection, public health programs, and household sprays and for disinfection of storage warehouse for the protection of agricultural protection. In agriculture, as Singh (2001) cited, the use of pesticides starts from the pre-sowing stage. The soil is treated against nematodes (worms) before sowing. Then, the seeds are treated against seed-born diseases. The standing crops are treated with pesticides against damage from pests, insects, rodents, etc. However, the use of pesticides can cause adverse effects on human health and on the environment. But, it is important to realize that the biological factors cause a loss of about 35 per cent of world agricultural outputs. According to Singh (2001), this includes 14 per cent due to harmful insects, 12 per cent due to diseases, and 9 per cent due to weeds.

2.9. Adoption of modern Agricultural Technologies

Adoption is an outcome of a decision to accept a given innovation. Feder, Just and Zilberman (1985) while quoting Roger's earlier work of 1962 define adoption as "a mental process an individual passes from first hearing about an innovation to final utilization" Much scholarly interest on adoption falls in two categories: rate of adoption, and intensity of adoption.

Adoption process is the change that takes place within individual with regards to an innovation from the moment that they first become aware of the innovation to the final decision to use it or not. Farmers accept innovations not immediately but after thinking over it taking time. Ekong (2003), stated several well-known schemes for explaining the adoption process such as awareness, interest, evaluation, trial, and adoption. It is well known that some people are more innovative (responsive to new ideas) than others. Innovativeness generally can be related to other personal characteristics: background, social status, associations, and attitudes (Ogunbameru, 2001).

As Ray (2001), emphasized, adoption does not necessarily follow the suggested stages from awareness to adoption; trial may not be always practiced by farmers to adopt new technology. Farmers may adopt the new technology by passing the trial stage. In some cases, particularly with environmental innovations, farmers may hold awareness and knowledge but because of other factors affecting the decision making process, adoption may not occur.

Dasgupta (1989), indicated that, the decision to adopt an innovation is not normally a single direct act, it involves a process. The adoption is a decision-making process, in which an individual goes through a number of mental stages before making a final decision to adopt an innovation. Decision-making process is the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision (Ray, 2001).

The rate of adoption is defined as the percentage of farmers who have adopted a given technology. The intensity of adoption is defined as the level of adoption of a given technology. The number of hectares planted with improved seed (also tested as the percentage of each farm planted to improved seed) or the amount of input applied per hectare will be referred to as the intensity of adoption of the respective technologies (Nkonya *et al.,* 1997).

In this study, a technology, as it relates vegetable growing, is a set of practices integrated into a package that aims to control specific pests on select crops in a manner that is proven more effective than the conventional means. Besides to this, fertilizer is one of the significant tool to increase yields. In general, several stages precede adoption. Awareness of a need is generally perceived as a first step in adoption process (Rogers, 1983). The other stages are: Interest, Evaluation, Acceptance, Trial, and finally, Adoption (Lionberger, 1960).

2.10. Farmers` adoption decision

Adoption is not a sudden event, but a process. Farmers do not accept innovations immediately; they need time to think over things before making a decision. Farmers are assumed to make decisions based upon an objective of utility maximization. This utility function depends on household specific characteristics. The decision to use or adopt an improved technology by a farmer involves a series of stages, which include Awareness, Interest, Evaluation, Trial, and Adoption (Rogers, 1995).

However, as emphasized by Ray (2001), adoption does not necessarily follow the suggested stages from awareness to adoption; trial may not be always practiced by farmers to adopt new technology. Farmers may adopt the new technology by passing the trial stage. In some cases, particularly with environmental innovations, farmers may hold awareness and knowledge but because of other factors affecting the decision making process, adoption may not occur.

Because of increased scientific research and improved methods of technology, a great variety of new materials and ideas have been generated and brought to the doors of the farmers and other rural food processors. The rates at which these people learn innovations and adopt them however differ greatly from one place to another. The rate of adoption of technology is important in assessing the effect of technology on the users. The rate of adoption could be seen as the proportion of farmers utilizing a particular innovation within a specified period. (Rogers, 1995).

2.11. The role of extension in enhancing adoption

The main role of extension in many countries in the past was seen to be move of new technologies from examiner to the farmers. Now it is seen more as a method of serving farmers to make their own choices by increasing the variety of alternatives from which they can choose, and by helping them to develop insight into the cost of each option (Ban and Hawkins, 1996). Extension plays a great part in popularizing farm technologies. Currently, everyone is found in competitive globalized world. Hence, to make the farmer fit; it is expected from the extension to work intimately with farmers than any other times. As noted by Hagmann, *et al* (2003) the role of extension includes: -

1. Building the capability of farmers and farmer organizations to pursue their development goals by articulating high quality demand for services. This could be suffering from providing need-based practical training and close follow up which enable them to examine their farming environment comparing with other farming situation. This, in turn, develops farmers' target for change through adopting different farm technologies that is appropriate to their farming system,
2. Linking farmers and farmer organizations to alternative support organizations as well as markets and input supply systems, creating platforms for their interaction and facilitating negotiation between the different stakeholders,
3. Serving to farmers search around for new information and technologies similarly as creating partnerships that enhance application of the information and technologies,
4. Facilitate farmers for collective and individual learning about innovations to boost community's capacity to initiate. Collective action helps to find out appropriate solution. Hence, participating different actors in learning and experimenting together and sharing experiences that enhance them to

understand more about the technology. Enhancing technology dissemination and adoption is part of an innovation system that starts with the technology development process itself. Concepts of participatory technology development (PTD) and now integrated agricultural research for development (IAR4D) indicate a shift from supply driven to more collaborative ways of generating and disseminating relevant agricultural technologies.

This therefore, means that the responsibility to promote technologies cannot be left to extension agencies alone but rather a collective responsibility of researchers, extension agents, farmers and other service providers. Engaging in such collective responsibility demands new skills for integration and working together in partnership with key stakeholders. Skill for doing so has to be clearly identified and deliberately built in the system (National Agricultural Research Organization, 2004) rural knowledge management that links various actors who have and seek knowledge to bring together their knowledge and experiences.

2.12. Intensity of Fertilizer of use and volume of use of Pesticide in the study area

Information on fertilizer use illustrates that the overall average fertilizer (both Urea and DAP) use per household and per hectare in the region was 40.18 kg and 46.33 kg, respectively. Likewise, the overall average manure use per household and per hectare in the region was found to be 623.76 kg and 878.48 kg, respectively(Teame, 2010). Various socioeconomic factors were hypothesized to influence adoption and intensity of use.

In this study, the specific technologies are fertilizer and pesticide. In the past six years, about 5,477.5 ‘quintal’ fertilizer is used in Mekelle city in all farming types. When we see its trend of using, the amount used was decreasing from 2674.5 quintal to 143.75 quintal, in 2000 E.C and 2004 E.C respectively. Though not as many of 2000 it increased to 2248 quintal in 2005 E.C. From this we can understand that adoption of fertilizer in the city is uncertain. Adoption of Pesticide also has the following condition as seen on table 2.12.1. Despite the using condition of pesticide can be determined by the invading of pests, it also showed decreasing trend.

Table 2.1 Fertilizer use (in kg) for the years 2000 and 2005 E.C

Variables	year						Total
	2000	2001	2002	2003	2004	2005	
yearly used fertilizer in 'quintal'	2674.5	114	154	143.5	143.75	2248	5477.75
Yearly used pesticides in litters	-	46	138	28	14	40	266 L

Source: data from the office mekelle city, 2013

According to the survey result, out of 204 respondents 97 households which is 47.55% of the total were found used fertilizer. And its minimum and maximum used was 0.25 and 4 quintal, respectively. To the one hand, pesticides were found used and it was 1 litter and 6 litters minimum and maximum, respectively. This is shown in table 4.2.17.2.

Table 2.2 used chemical in the sample household

Variable	obs	Mean	Std. Dev.	Min	Max
Used Fertilizer	97	1.574742	0.8078109	0.25	4
Used Pesticide	93	2.129032	1.146007	1	6

Source: computed from own survey, 2014

2.13. Empirical Literature

Feder et al.(1985), summarized the vast amount of empirical literature on adoption and indicated that the constraints to adoption of new technology may arise from many sources, such as lack of credit, inadequate farm land, unsuitable supply of complementary inputs, limited access to information, uncertainty and so on. Schultz (1995), suggested many testable hypotheses: that the probability of adoption of a new technology will depend on the difference in profitability between the new and old technologies, and the ability of farmers to perceive the advantages and efficiently utilize the new technology.

Kebede et at. (1990), conducted a study on adoption of new technologies in Ethiopia agriculture in Tagulet-Bulga district, shoa province and found that education level of farmers had positive effect on the adoption of new technologies in Ethiopian agriculture. A study conducted by Degnet and Belay (2001) on factors influencing the adoption of high yielding maize varieties in southwestern Ethiopia underlined those factors such as age of the farmers, frequency of contact with extension workers, annual on-farm income level and farmers' knowledge of fertilizer use and its application rate significantly affected farmers adoption decision.

Wolday (1999), conducted a study to understand the major factors, which dictate the use of improved seed in Ethiopia and reported that, price of inputs, access to credits, fertilizer use, economic status of the household, size of land owned, visit of extension agents and infrastructure development are the principal determinants of the adoption of improved seed. Teresa(1997), in his study on factors affecting the adoption of fertilizer in Lume area, found that extension service, number of oxen owned, access to credit and labor were among the important determinants of the decision to adopt fertilizer. The rate of adoption was attributed to farm size, family size, hired labor off-farm income to which results of innovation are visible to farmers.

A study conducted by chilot (1996), in Wemera and Addis Alem areas of Ethiopia showed that the adoption of improved wheat seeds is positively and significantly influenced by the wealth status of the farmers, farmers' contacts with extension agents and availability of fertilizer on time.

A study conducted by Lelissa (1998), on determinants of fertilizer adoption, intensity and probability of its use in 'Ejere' district, west 'shoa' zone of Ethiopia has also shown that agro-climate conditions, access to credit, extension service, oxen ownership, age of the farmer, family size, farmers level of education, distance to fertilizer distribution center and pattern are the most important determinants of fertilizer adoption and intensity of its use.

Tesfaye et al. (2001), conducted a study on the adoption of high yielding maize technology in major maize growing regions of Ethiopia and the results revealed that distance to the nearest market center, family size, livestock holding in terms of tropical livestock unit, access to credit, significant and positively influence the adoption decision of improved maize.

Ezeilo (1979), argues that adoption of new technology is best promoted by means of integrated package of farm support measures, availability of credit, marketing, input supply services, improved transportation, price incentives, and the establishment of cooperative ventures to overcome constraints due to new technology and to ensure its success. Oyenwaka (1991), discovered profitability to be the major reason for adoption while the most limiting factor was lack of awareness of the technology.

Yusuf (2009), found rate of adoption of improved technologies to be relatively higher, because the technologies were easy to operate. Idrisa *et al.* (2008), found higher rate of adoption of the recommended practices to be due to its affordability to the respondents. Other factors associated with adoption as confirmed by other researchers include: gender, age, education of household head, family size and other demographic traits that make up the household characteristics (Clark and Akinbode, 1986).

A study carried out by Teame (2011), in northern ethiopia, tigray region showed that the determinant factors of fertilizer adoption of the peasant farm sector in the region, used '*panel Probit model*' that variables like education of the head of the household, adult labor of the household, farm size, number of plots, average plot distance from homesteads, oxen ownership, market distance were found significantly determinant of the likelihood of adoption of fertilizer. Using '*Tobit model*', he also attempted to identify the influential factors that are associated with the intensity of fertilizer use by all households and those were found that household education, farm size, manure use, plot number, plot distance, and oxen holdings.

Tadesse (2009), conducted a survey on analysis of factors determining the adoption of agricultural inputs through multipurpose cooperatives in 'Tahtay-Koraro' wereda, north western zone of Tigrai, Ethiopia found sex of the household, educational level, farm size, livestock ownership, family size, contact with extension agent, distance from the extension service, access to improved seeds, access to input credit, input price, product price, and annual income as the significant determinants of fertilizer adoption. On the other hand, the determinants of intensity use of fertilizer were found to be sex of the household head, access to input credit, distance to extension service, and farming experience. To reach in to this decision, he used the Logit model.

The result of study conducted by Kouame (2011), concerning *“adoption and levels of demand of fertilizer in cocoa farming in cote divoire”* using Hechman model consisting two-steps(binary probit model) showed that factors that tend to significantly affect fertilizer adoption decision were “*education, membership of association, liquidity, farm size, hired labor, soil fertility, risk aversion and risk perceptions.”* In the other hand, in his intensity use of fertilizer, he showed that variables like “*education, access to credit, membership of association, farm size, soil fertility and risk aversion”* were the most important determinants of the level of demand for fertilizer in cocoa farming. To reach in to his conclusion, he employed Ordinary Least Squares model (OLS).

A study conducted by Jaga, (2012), stated “An Overview of Fertilizers Consumption in India: Determinants and Outlook for 2020-A Review” using simple linear regression model using ordinary least squares (OLS) method depicted that Price of fertilizers, irrigation, cropping intensity, Availability of capital, input price and price of agricultural output were found the significant determinant of intensity use of fertilizer.

Another study conducted by Yuan Zhou(2010), regarding Factors affecting farmers’ decisions on fertilizer use: A case study for the Chaobai watershed in Northern China apply an ordinary least square (OLS) estimation to explain the variation in fertilizer use intensity. The study showed that variables like age, education, farm size, irrigation, liquidity variables (off-farm work and household agricultural assets), Distance from fertilizer market, Manure, cost of fertilizer, farming goals. However, two other variables—the yield gain from fertilization and soil fertility—do not appear significant.

A study that conducted by akinlade(2013), was used Tobit regression model, to estimate the determinants of fertilizer use among smallholder food crop farmers in ‘ondo’ state, Nigeria. The result depicted that the significant factors influencing fertilizer use intensity in the use of fertilizer in the study area were education, distance to market, membership of farmers’ group, farm size, access to credit and fertilizer price.

Sntayoh (2013), conducted a study on *“Role of Seed Producers and Marketing Cooperative on wheat crop production and Its Implication to Food Security(Endamokoni Woreda, Tigray, Ethiopia)”.* He used Hechman two-step model(Binary probit model), and as a result of the study, household head age, irrigation, Social leadership participation, Farmer’s perception on cooperatives, and Tropical Livestock unit were significant determinants of the participation of improved wheat crop adoption. Moreover, using heckman outcome model, he assured that age of household head, household size, size of cultivated land, tropical livestock ownership, access to extension service, participation in training, and the inverse Mills ratio were factors that affect household Wheat crop production.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Site Selection and Description of the Study Area

Mekelle is the capital city of Tigray National Regional State. The total population of the city in reference to the 2007 census was 215,914 of which 104,934 (48.6%) were males and 110,980 (51.4%) females. This was then projected to reach 272,519 in 2013 of which 132,444 are males and 140,075 females. The current population is therefore approximately 272,519. The total area covered by the city is estimated to be 19,200 hectares /192 kilometer square/ (Tigray Regional Bureau of Plan and Finance, 2011).

Mekelle is now the centre of political, social, and economic activities of the Regional State. In the past few years, various development efforts have been undergoing in the city. Mekelle University and other public & private higher learning institutions are also believed to have further strengthened the capacity and economic development of the City. There are also nine government branches and private banks including Dedebit Microfinance and nine insurance companies. It has also one international airport called Alula Abanega.

In addition, there are 824 micro- and small enterprises employing 15,546 youths and 467 cooperatives engaged in different sectors creating employment opportunities for 6,564 people. There are also industries and manufacturing firms operating in the city (Bureau of Plan and Finance, 2011). All these economic activities make Mekelle city favorable for business and investment. Here in the city, urban agriculture (UA) is also practiced in different sectors and sun-sectors, such as irrigation, animal rearing, beekeeping, etc. Irrigation users account about 4009 and of them more than 60% are vegetable growers (ADEMEO report, 2013). These vegetable growers are supplying fresh vegetable to the city in a significant amount. Thus, it is believed that vegetable cultivation in mekelle city is benefiting for both the growers and consumers. Therefore, the main reason for selecting vegetable growers in the City as a study area is its importance of socio-economic benefits such as self-sufficiency, nutritional value, income generation, job creation, etc.

3.2. Data source and sampling process

The study used both quantitative and qualitative data. The primary data source included information collected from targeted respondents (technology adopter and non-adopter of vegetable producers) using structured questionnaires. The secondary sources has included vegetable growers' and technology adopters' data base, technology adoption performance reports, study documents, and the like.

The survey sites are selected based on intensity of vegetable production zones in the city. The sample size is determined based on the percentage of total vegetable production in major vegetable production sub-cities. Here in the city, the population is sized 4009 irrigation users, which from these 60% are estimated vegetable grower household/firm heads (ADEME office's semi-annual report, 2013).

The sampling technique has followed judgmental of the high population growers in the city administrative ('Weredas' in local terms). Here out of seven (7) sub-city, five sub-cities with significant number of vegetable growers, namely "Ayder"(609 irrigation users*60%=365 vegetable growers), "Hawelty"(554*60%=332 vegetable growers), "Hadnet"(499*60%=299 vegetable growers), "Semen"(497*60%=298 vegetable growers), and "Quiha"(377*60%=226 vegetable growers) has selected. Totally, expected vegetable growers in the five sub-cities were 1521(=2536*60%). Once the sub-cities with high populated grower have been selected, proportional sampling process has adopted to obtain the proportionate number of households. Afterwards, systematic sampling technique has adopted to obtain the required sample size.

The determination of an appropriate sample size is the primary part of sample design. According to Israel (2013) in addition to the purpose of the study and population size, the level of precision, the level of confidence or risk, and the degree of variability in the attributes being measured were needed to be specified to determine the appropriate sample size. Accordingly, the study has intended to use Yamane's simplified formula as described in Israel (2013, page 5). The formula, which is depicted here after, assumes degree of variability (proportion) of 5% and a confidence level of 95%, which is appropriate to use in social sciences researches.

The formula is:

$$n = \frac{N}{1+N(e)^2}$$

Where:
n=sample size
N=population size
e=the level of precision

Therefore, the study sample size is:

$$n = \frac{1521}{1 + 1521(0.05)^2}$$

$$n = \frac{1521}{7.34}$$

$$n = 207\ vegetable\ growers$$

The next question is how had selected these respondents from among the 1,521 vegetable growers? First, I have decided to select the sample units from the abovementioned five Sub-Cities vegetable growers weighing its importance. Then, probability sampling has used to select the samples randomly which avoids subjectivity as compared to the non-probability sampling procedures. For this purpose, lists of vegetable growers of the five Sub-Cities have obtained from the office urban agriculture of Mekelle city, which serves as a sample frame or working population. Then, the sampling units have drawn from each sub-city that could be taken as stratum proportionately (Zikmund et al., 2012). Accordingly, the 207 vegetable growers are then prorated to the five sub-cites. Based on the applied Judgmental sampling, here the result is shown below in table.

Table 3.1 selected samples for the study

Name of selected sub-city	Vegetable Growers		
	No of growers	% share	Sample units selected (%*207)
Ayder	365	24	50
Hawelti	332	22	46
Hadnet	299	20	41
Semen	298	19	39
Quiha	226	15	31
Total	2,536	100	207

Source of Data: Office of urban agriculture of Mekelle City, 2014

The final sampling procedure was to select the actual respondents from each the five sub cities. With this sampling procedure a first sample interval has established by dividing the target population of each sub-city by sampling units selected for that sub-city. Then the starting point or the 1st vegetable grower is selected by a random process and after that every nth number on the list of vegetable growers has been selected. This can be elaborated a bit using 50 sampling units of vegetable grower from “Ayder” sub-city as an example. Thus, 365 were divided by 50 to establish a sample interval, which gave 7. Then the sample interval was 1-7. A number from this interval is selected randomly to get the first vegetable grower for the inclusion in the actual sample. For example if the number 5 was selected, the next selection was (5+7)th and so on. Therefore, by using the same procedure all the 207 vegetable growers were selected scientifically. I hope that this will serves the specific purpose of the research.

3.3. Data Collection and Instruments:

I have used both quantitative and qualitative data collection instruments to obtain the desired information both from primary and secondary data sources. Accordingly, the instruments were:

Questionnaire: A structured questionnaire has been designed to reveal the comprehension of typical growers. The sampling was random in the selected highest vegetable growing zones. Two settlement zones were identified: (1) peri-urban zones (a transition or interaction zone, where urban and rural activities are put beside, and landscape features are subject to rapid modifications, induced by human activities); and (2) urban zones (higher population density and vast human features in comparison to areas surrounding it).

The survey questionnaire has made up of following categories of questions, which is based on households socio-economic characteristics, institutional factors, and extent of technology adoption. It is recognized that information retrieved from interview with individual growers could be variable because of the differences in sex, age, division of labor and literacy level. Then, the questionnaire is distributed to treated and controlled groups to collect the required data.

3.4. Method of Data Analysis

Up on gathering all relevant primary and secondary data, the task of data analysis on the factors affecting adoption of agricultural technologies in the case of chemical Fertilizer and Pesticides in Mekelle city-vegetable growers was carried out. Furthermore, the primary data are collected from the sample survey and analyzed by employing statistical software application called STATA. Besides, an econometric analysis called *'Heckman model'* has used to address the factors that affect adoption of agricultural technology in the city; and to check whether technology adoption brings higher income for the adopter in comparison to their counterparts. In addition to this, Least Ordinary Square has used also to see the intensity of use of the technology. Then the study stated about the research out comes, conclusions and policy implications.

3.5. Model Specification

This study has three objectives as mentioned in the objective part above. The two objectives are met by applying Heckman two stage selection models. Here the model enabled the study to investigate factors that affect the technology adoption (fertilizer and pesticide) and to examine whether technology adoption brings to higher financial gain of the adopters in comparison to non-adopters. For the intensity of use "Ordinary Least Square" is used. In the heckman, "probit" model is used. In the probit model, the households are assumed to make decisions based upon an objective of utility maximization. For a given decision, separate models are developed for each decision. The underlying utility function depends on household specific attributes *X* (e.g. age of household head, sex of the household head, education, membership to an agricultural association, access to credit, etc) and a disturbance term having a zero mean:

$U_{i1}(X) = \beta_1 X_i + \varepsilon_{i1}$ for adoption (1)

And $U_{i0}(X) = \beta_0 X_i + \varepsilon_{i0}$ for non-adoption. (2)

As utility is random, the i^{th} household selected the alternative "adoption" if and only if $U_{i1} > U_{i0}$. Thus, for the household *i*, the probability of adoption is given by:

$P(1) = P(U_{i1} > U_{i0})$ (3)

$$P(1) = P(\beta_1 X_i + \varepsilon_{i1} > \beta_0 X_i + \varepsilon_{i0}) \quad (4)$$

$$P(1) = P(\varepsilon_{i0} - \varepsilon_{i1} < \beta_1 X_i - \beta_0 X_i) \quad (5)$$

$$P(1) = P(\varepsilon_i < \beta X_i) \quad (6)$$

$$P(1) = \Phi(\beta X_i) \quad (7)$$

Where: Φ is the cumulative distribution function of the standard normal distribution. The parameters β are estimated by maximum likelihood x′ is a vector of exogenous variables that explains adoption. In the case of normal distribution function, the model to estimate the probability of observing a farmer using a new technology can be stated as:

$$P(Y_i = 1/x) = \Phi(x'\beta) = \int_{-\infty}^{x'\beta} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{z^2}{2}\right) dz \quad (8)$$

Where - P is the probability that the i^{th} household used the new technology and 0, otherwise.

- Y_i Farmer adoption decision which takes the value of 1 if he is adopting and 0, otherwise

The probability of adopting the technology is estimated by means of a Probit maximum likelihood function on both fertilizer/pesticide users and nonusers. The choice of fertilizer/pesticide adoption by the i^{th} household is modeled by the following selection model:

$$Y^* = x'\beta + \varepsilon \quad (9)$$

Where Y^* is an unobserved latent variable determining a household's decision to use fertilizer/pesticide, β is a vector of farm households' asset endowments, household characteristics and location variable hypothesized to affect the adoption decision, and ε is the random disturbance term distributed with mean 0 and variance 1. The observed binary variable will be:

$Y = 1\ if\ Y^* > 0$, (for users of fertilizer/pesticide)

$Y = 0\ if\ Y^* \leq 0$, (for non-users of fertilizer/pesticide) (10)

From the Probit equation the inverse of the Mill's ratio, LAMBDA (λ), which is the ratio of the ordinate of a standard normal to the tail area of the distribution, can be computed (Heckman 1980). The Mill's ratio reflects the probability that an observation belongs to the selected sample and is obtained as follows:

$$\hat{\lambda}_i = \frac{\phi(X_i\hat{\alpha})}{\Phi(X_i\hat{\alpha})} \qquad (11)$$

Where: $\emptyset$ is the density function of a standard normal variable, Φ is the cumulative distribution function of a standard normal distribution and λ is the Mills ratio term.

In the second step, λ is included as an additional variable in the outcome equation for fertilizer/pesticide - using households. This technique eliminates the potential sample selection bias. If λ is not statistically significant, then sample selection bias is not a problem (Heckman 1980). The regression equation for the fertilizer of use or pesticide volume of use is given by:

$$y_i = \beta_0 + \beta_1 W_1 + \beta_2 \hat{\lambda}_i + \xi_i \qquad (12)$$

Where: y is defined as the sales income from fertilizer/pesticide adoption, W is a vector of farm households' asset endowments, household characteristics and location variable affecting the sales income from of fertilizer/pesticide users, ξ is the new residual with the property that $E(\xi) = 0$ (Maddala, 1999).

As mentioned earlier, OLS is used for the objective that deals with intensity of use of the technologies.

The model for the intensity of use of fertilizer and/or volume of use of pesticide is given bellow.

Y = f (hhage, hhagesq, Educ, Gender, Hhsize, Fmexp, Costfert, percfert,
Manu, Fertility, disfarm, Dismkt, Extsuppo, Credit, Farmsize,
offfarm, scarwat, hhincome, gofarm, ei)---13

Where:

y = the intensity of use of fertilizer and/or volume use of pesticide within the adopters

ei = the error term in the model.

hhage= age of household head

educ= education level of household head

gender= sex of household head

farmsize= farm land size

costfert= cost of fertilizer

percfert= perception of fertilizer

manur= animal dung

fertility= soil fertility

disfarm= nearness of farm land

dismkt= nearness of farm land to homesteads

extsuppo= support of extension support

credit= access to credit

farmsize= size of farm land

offfarm= off-farm engagement

scarwat= scarcity of water for irrigation

hhincome= household income

gofarm= purpose of farming

Here in the model, several dependent variables are analyzed. The dependent variables are whether the farm household used fertilizer and pesticide or not, the income gain from sale of vegetables of the adopters, and the intensity of fertilizer use and/or volume of pesticide use. Explanatory variables are gender of the farm household head, age farm household head, level of formal education of farm household head, nearness to market from farm land, access to credit, nearness of farm land to homesteads, land accessibility, and the like. More detail on dependent and independent variables has provided in the next section.

3.6. Selection of Regressors and expected sign

As the study was all about Adoption of Agricultural Technologies within Vegetable producers of urban farmers and the practice of urban farming, the vector of Regressors lied mainly within these household/farmer variables.

Some literature argue that intrinsic and extrinsic household motivations such as intertemporal orientation, environmental concern, age, income, gender, household size, distance, attitude towards agriculture and infrastructures of farming facilities, land ownership, etc have direct and indirect effect on urban farming managements.

In this section, we present the variables used in the analysis. First, farmers decide whether they will use fertilizer (*fertadop*) and/or pesticide (*pestadop*). Second, they make a decision regarding intensity of use, represented here by the rate of fertilizer application per hectare (*usefert*) and/or pesticide (*usepest*). A summary description of the variables included in the empirical model is given in table 3.2.

Table 3.2 Summary of definitions and descriptive statistics of variables used

	Variables	Explanation	mean	Std. Dev
Dependent variables	fertadop	Adoption of fertilizer; dummy =1 if the grower uses fertilizer, and 0 otherwise	0.475	0.501
	pestadop	Adoption of pesticide; dummy =1 if the grower uses fertilizer, and 0 otherwise	0.456	0.499
	usefert	Amount of fertilizer in kilograms per hectare used on the plot	1.575	0.808
	usepest	Volume of pesticide in litters per hectare used on the plot	2.129	1.146
	incvegsale	Income generated from vegetable production scheme via adoption of modern farm technology like fertilizer and pesticides(in birr)	17036.22	17103.69
Independent variables	*Farmer Characteristics*			
	hhage	Age of the household head in years: continuous	42.735	10.267
	educ	Education level of the household: Dummy = 1 if literate, 0 otherwise	0.824	0.382
	gender	Sex of household head: Dummy = 1 if the household head is male, 0 otherwise	0.926	0.262
	hhsize	Household size: number of household members: Continuous	6.225	1.572
	fmexp	Farming Experience on vegetable cultivation in years: continuous	5.456	4.318
	percfert	Farmers perception on chemical fertilizer: Dummy = 1 if good perception, 0 otherwise	0.603	0.490
	attipest	Attitude towards pesticide: Dummy = 1 if good attitude, 0 otherwise	0.838	0.369
	marital	Marital status: Dummy=1 if married, 0 otherwise	2.044	0.319
	Farm Characteristics			
	farmsize	Size (in hectares) of land used by the household for vegetable growing: continuous	0.434	0.327
	gofarm	Purpose of growing vegetable: Dummy = 1 if market purpose, 0 otherwise	0.975	0.155
	scarwat			
	costpest	Cost of pesticide: Dummy = 1 if cost is high, 0 otherwise	0.637	0.482
	costfert	Cost of fertilizer: Dummy = 1 if cost is high, 0 otherwise	0.765	0.425
	fertility	Soil fertility: Dummy = 1 if the soil is fertile, 0 otherwise	0.564	0.497
	manur	Organic Manure: Dummy = 1 if the household head used manure, 0 otherwise	0.985	0.121
	Off-farm	Off-farm engagement: Dummy = 1 if engaged in off-farm, 0 otherwise	0.221	0.416
	hhincome	All income of the household at specific time(continuous)	48312.87	49286.32
	Location			
	disfarm	Nearness of the household to the farm land: continuous	1.401	1.300
	dismkt	Nearness of market to farm land: continuous	3.639	2.928
	Institutional factors			
	extsuppo	Support of extension agents: Dummy = 1 if got extension support, 0 otherwise	0.936	0.245
	credit	Use of credit: Dummy = 1 if used credit, 0 otherwise	0.608	0.489

Source: own definition

The discussions and hypotheses about the independent variables included in the model are provided below.

3.6.1. Dependent variables:

Adoption of technologies like fertilizer and pesticides are two dependent variable of the study. For the first stage of heckman model, adoption decision, which is dummy variable taking a value of one if the household adopts the agricultural technologies (fertilizers & pesticides) and zero otherwise. Besides, the amount/intensity adopted technologies of fertilizers and pesticides are continuous variables. For the heckman second stage analysis of Income from sales of vegetable is a continuous variable measured in birr.

3.6.2. Independent (explanatory) variables:

Farmer's decision to use fertilizer and pesticide and the intensity of their use in a given period is influenced by a combined of various factors. Those variables are thought to have influence adoption of agricultural technologies (fertilizers and pesticides) on vegetable growers and its implication to higher income. Those include household characteristics, socio-economic and institutional variables. Based on Feder et al. 1985, who extensively reviewed factors affecting adoption of agricultural technologies in low income countries, and on the brief of literature review in this study a total of 23 variables are hypothesized to explain fertilizer and pesticide adoption and intensity/volume of their use by the sample households of Mekelle city(MC) vegetable growers. Brief explanation of the selected explanatory variables is presented in the research findings of the independent variables such as:-

3.6.2.1. Household characteristics and socio-economic variables

- *Age of the household (age):* As farmers advance in age, risk aversion increases and adopting a new technology seems less likely (Daniel B., 2002). Moreover, it is believed that age is capable of influencing individual's interest, perception, view, attitude, conduct, and practice. This variable is expected to negatively affect the adoption of most technologies. This was measured based on the exact number of the respondent's years on earth. It has been documented that young people are more likely to take risks associated with innovation (Rogers 1995). We hypothesized that AGE is negatively related to the adoption of fertilizer.

- *Farming Experience (fmexp):* This was measured in years given that the respondent engaged in vegetable growing activities. Experienced farmers are assumed to have tried out a number of profitable technologies as experience helps an individual to think in a better way and makes a person more mature to take right decision (Rahman, 2007). Hence, the variable is expected to positively affect fertilizer and pesticides adoption.
- *Household Family size (hhsize):* New technologies increase the seasonal demand for labor, so that adoption is less attractive for those with limited family labor or those operating in areas with less access to labor markets (Feder et al., 1985). Labor availability is a variable which affects farmers' decision regarding adoption of new agricultural practices or inputs(ibid). In addition, much of the farm work in Ethiopia is done by family members (Croppenstedt et al. 1999). Therefore, it was expected that this variable would have a positive impact on adoption and intensity use. It is a continuous variable and was measured taking total number of household members.
- *Respondent's Gender (gender):* Female and male farmers are likely to play different roles in technology adoption, depending on the nature of the technology. Women-headed households are generally perceived to face more constraints than others and we expect them to be reluctant to adopt new technologies. therefore, the effect of this variable is indefinite.
- *Education level of the household (educ):* some empirical studies have demonstrated that literacy is the important factor for farmers' adoption decision and intensity of use (Croppenstedt, 1999). Farmers' with ability to read and write are expected to have an advantage in obtaining information and understanding the benefit of technology use. Respondents' exposure to education will increase the farmers' ability to obtain process and utilize information relevant to the adoption of fertilizer and pesticide technologies. Therefore, education was hypothesized to positively influence adoption decision and intensity of technology use. It was a dummy variable representing the education level of the head of the household. Where household heads that are literate= 1, otherwise 0.
- *Attitude towards pesticides (attipest):* A negative attitude on the technology of pesticides is likely to influence negatively the adoption of the technologies. It

was a dummy variable representing the education level of the head of the household. Where household heads that are good= 1, otherwise 0**.**

- *Total plot Size (farmsize):* Farmers' total land holding may serve as a good alternate for wealth and status and income levels. The vegetable growers, who have large sized plot of land/backyard/ have more chances to adopt technology. Therefore, farm size can be positively related to adoption because larger farmers can experiment with new technologies on portion of land without severely risking their minimum subsistence food requirement. This variable was measured in hectares.
- *Purpose of farming (gofarm)* farming for market purpose lets higher expected yields. In addition, higher expected yields from a crop may increase the probability of adoption of even more yield-increasing technologies. Therefore, goal of farming is expected to be positively correlated with adoption of fertilizer and pesticides.
- *Perception on cost of technology (costfert/costpest):* the cost of agricultural inputs may encourage/discourage farmers in order to use production enhancing inputs. If the cost regulation of inputs does not invite farmers, it will have negative effect on technology adoption. Therefore, this variable was expected to have negative relation with the dependent variables. It was dummy variable with value of 1 for high cost and 0 otherwise.
- *Soil fertility (fertility):* The more fertile of the soil is the less adoption of fertilizer. The purpose of applying fertilizers to the soil is adding nutrients to the soil so that to increase outputs. It is to be measured based on "0" if the soil is not fertile, "1" if the soil is average, ad "2" if the soil is fertile. If the soil is fertile the product raised from the land is sufficient. Therefore, fertility of soil and adoption of fertilizer have negative relationship.
- *Nearness of farm land to market (dismkt):* Access to market is hypothesized to be positively related to the probability of vegetable crop production. If the farm land located near to market, the households tend to buy agricultural inputs as they can have easy access to sell their produces in the market. As market distance increases adoption of technology decrease, and as a result, vegetable crop production are expected to decrease. The distant the market center is the lesser the income from the sale of farm produces. Especially for perishable products like vegetable if the market place is located far away from the farm,

the commodity may perish before arriving the market and to avoid such incidences the farmer sells his output for cheaper price and reducing the income.

- *Farmers perception on chemical fertilizer(percfert):* The pace of adoption is affected by the farmers` perception of the characteristics of the innovation (Ban and Hawkins, 1996). It was hypothesized that the total positive results of the perceived attributes (advantages and disadvantages of the technology) affects adoption positively.
- *Closeness of the household to the farm land(disfarm):* Household nearer to plot have better chance of managing and seeing ever growing of the vegetable, which in turn will improve vegetable production and productivity. Therefore, it is expected to positively influence the inefficiency score of farm household significantly.
- *Total household income(hhincome):* refers to the total earning of all members of the family of the respondents for one year. This can be obtained by adding the income earned by the family members and income from on-farm and off-farm for one year. Therefore, it would have positive influence on adoption and intensity use of the technology (fertilizers and pesticides).
- *Organic Manure (manur):* this is a dummy variable, which takes a value 1 if the households used manure and 0 otherwise. In this study manure refers to animal dung which household apply on their field to improve soil fertility and organic matter content to increase yields. It also improves the soil water holding capacity and thus increases efficiency in the use of inorganic fertilizer. In this case, the availability and use of manure is hypothesized to be positively related to the adoption of fertilizer. Regarding this variable different studies have reported different results. For instance, Lelissa(1998), reported that, using manure to the required level will probably reduce the chemical fertilizer adoption. Therefore, it was expected that this variable would have positive or negative effect.
- *Scarcity of water to irrigation(accesswat):* application of fertilizer needs sufficient water, unless otherwise, it can harm the crop(vegetable) at the time of insufficient water for irrigation. Even if there is water scarcity, farmer may either cultivate less land or stop growing at all. It was dummy variable with value of 1 for scarcity of irrigation water, 0 otherwise. Therefore, it is believed that scarcity of irrigation water can affect adoption of fertilizer negatively.

- *Off-farm engagement (off-farm):* this is a dummy variable, which takes value 1 if any member of the household is involved in off-farm, work for payment and 0 otherwise. Off-farm income is a very important source of cash for farm households especially to buy fertilizer(readon et. Al 1999). However, in certain cases the effect is ambiguous. Teressa (1997) reported that, farm household who were involved in the generating of off-farm income tends to intensify less their crop production. There are cases when off-farm income looks relatively attractive the attention of households. Therefore, it was expected that off-farm income would have either positive or negative impact on adoption decision.

3.6.2.2. Institutional factors

- *Support of extension agents(extsupp):* Feder (1985), illustrated that extension efforts boost the probably of adopting new technology by rising the stock of information pertaining to modern production growth. This is a dummy variable, which takes a value 1 if the household received extension service and 0 otherwise. Extension visits will help to reinforce the message and enhance the accuracy of implementation of the technology packages (Oladele, 2005). If the households get better extension service, they are expected to adopt the technologies than others. Therefore, it was hypothesized that this variable positively influences adoption and intensity of fertilizer and pesticide use.
- *Access to credit (credit):* In the literature it has been argued that the lack of credit is a constraint to adoption (Augustine and Mulugeta, 2005). Thus, lack of initial capital hinders the farmer from adopting the technology, particularly resource poor farmers. This is a dummy variable, which takes a value 1 if the farm household has access to input credit and 0 otherwise. In the present study, it is hypothesized that access to credit would have positive influence on adoption and intensity of fertilizer and pesticides.

Two technologies that are examined in this study are: Fertilizer and pesticides. Besides, their quantities are concern of this survey. How the adoption of the technologies leads to higher financial gain of the vegetable growers who adopt those technologies is also another third concern of this study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4. Introduction

This chapter presents the outcomes of the descriptive and econometric analyses. The tools of the descriptive analysis use are such as mean, percentage, standard deviation, and frequency distribution. Additionally, the t- statistics is employed to compare adopter and non-adopter groups with respect to some explanatory variables. Econometric analysis is carried out to identify the most important factors that affect the adoption decision of technology and to measure the relative importance of significant explanatory variables on the technology adoption. Intensity/volume of use of fertilizer/pesticide per hectares was also another focus point of this study. In addition, income generated from vegetable production scheme via adoption of modern farm technology like fertilizer and pesticides has seen and compared with the income of the non-adopters. This analysis was made in the concept of the stated objective of the study.

4.1. Descriptive statistics

Mekelle city(MC) has seven sub-cities. Of the seven sub-cities, the five sub-cities, which have significant number of vegetable growers (VG), are selected to this study. In 2013/2014 fiscal year there were 1521 growers in the five sub-cities. Therefore, a total 207 growers (about 14%) were selected by multiple stages sampling method but because of inappropriate completion of three questionnaires, a total of 204 farming households were used for the study.

4.2. Demographic Characteristics of respondents

Here in the study, two types of technology, namely, fertilizer and pesticides are seen as a separated technology. For this reason, we have seen the two technology adopters in a separate manner as follows.

4.2.1. Age of the household head

As we see the result of survey on the following table, the average age of the sample household head is 42.74 years whereas the minimum and the maximum are 26 and 73, respectively. The average household age of fertilizer adopters is 45.05 and their corresponding figure for non-adopters is 40.64. From the statistical analysis performed, it is found out that the mean age difference between adopters and non-adopters of fertilizer technology is statistically significant telling that age has an influence on the adoption decision.

To the other hand, the average household age of adopters of pesticides is 41.73, and the corresponding figure for non adopters is 43.58. From this statistical analysis, it is found out that the mean age difference between the users and non-users is not statistically significance (table 4.2.1 bellow).

Table 4.2.1 Age of the Household Head(for both technologies)

Description	Sample HH	Chemical fertilizer		Pesticides	
		Adopter	Non-adopter	Adopter	Non-adopter
Total	204	97	107	93	111
Mean	42.74	45.05	40.64	41.73	43.58
St.dev	10.27	10.40	9.72	10.43	10.10
t=value		t= -3.1338		t= 1.2806	
Minimum	26				
Maximum	73				

Source: from own survey data, 2014

4.2.2. Family size of the sampled households

According to the study, the average household *size* of the total sample households is about 6.23, with 3 and 10 being the minimum and the maximum household sizes respectively. The average household size for adopters of fertilizer is 6.67 and 5.82 for the non-adopters. The mean comparison of household size between the two groups illustrated that statistically there was significant difference in the mean household size between adopters and non-adopters of fertilizer.

In relation to the pesticide, the study revealed the average household size for the pesticide adopters is 6.18 and 6.26 for non-adopters. The mean comparison of household size between the two groups showed that statistically it is not significant difference in the mean household size between the groups..

Table 4.2.2 Household size(for both technologies)

Description	*Sample HH*	Chemical fertilizer		Pesticides	
		Adopter	Non-adopter	Adopter	Non-adopter
Total	204	97	107	93	111
Mean	6.23	6.67	5.82	6.18	6.26
St.dev	1.57	1.31	1.68	1.53	1.61
t=value		t=-3.9848		t=0.3543	
Minimum	3				
Maximum	10				

Source: own survey, 2014

4.2.3. Sex of the household head

According to the survey result, 7.35 percent of the sample households headed by females and the rest 92.65 percent are headed by male. When we see the comparison by fertilizer adopters, out of the user households, 7.22% are headed by female and the corresponding figure for non users is 12.15%. The chi square test showed that there is no relationship between sex of the household head and adopting fertilizer.

When we see in the perspective of pesticide, the survey result shows us, when we see the comparison of adoption 6.45% are headed by female and the corresponding figure for non-adopters is 12.61%. The chi square test showed that there is a relationship between sex of the household head and using pesticides(table 4.2.3).

Table 4.2.3 Sex of the Household Head (for both technologies)

Description	Sample HH	Chemical fertilizer		Pesticide	
		adopter	Non-adopter	adopter	Non-adopter
Total	204	97	107	93	111
Female	20(7.35%)	7(7.22%)	13(12.15%)	6(6.45%)	14(12.61%)
Male	184(92.65%)	90(92.78%)	9487.85%)	87(93.55%)	97(87.39%)
		chi^2 = 1.4001		chi^2 = 2.1722	

Source: own survey, 2014

4.2.4. Size of cultivated land

The land holding of the sample household varies from 0.03 ha to 1.25 ha. The average land holding of the sample household is 0.434 ha. Besides to this, the mean land holding for fertilize adopters is 0.59 ha and the corresponding figure for non users is 0.29 ha. The t-test (-7.2991) revealed that mean difference between the two groups is statistically significant. Moreover, it is quite true that in a normal circumstances land size and land productivity are direct and positively related.

Considering this, finding in the survey confirms that size of cultivated land has influence in adoption of fertilizes. However, as many researchers illustrated, application of fertilizer (either chemical or organic) depends on the fertility of the soil. In relation to the survey, 64(65.98%) adopter of fertilizer have fertile land and remain 33(34.02%) of the adopters have either average or infertile plot(table 4.2.4.). To the other hand 66(61.68%) non adopters have fertile plot but the 41(38.32%) non adopter have either average or infertile plot. In general, 130(63.73%) household of the sample are with fertile plot and 74(36.27%) household have either average or infertile plot. The chi square test indicated that there is positive relationship but not significant between adopters of fertilizer and soil fertility.

When we see from the angle of pesticide technology adoption (PTA), the mean land holding for users is 0.40 ha and the corresponding figure for the non users is 0.46 ha. The t-test revealed that mean difference between the two groups is statistically not significant (table 4.2.4.).

Table 4.2.4 Size of cultivated land(for both technology)

Description	Sample HH	Chemical fertilizer		Pesticides	
		Adopter	Non adopter	Adopter	Non adopter
total	204	97	107	93	111
Mean	0.43	0.59	0.29	0.40	0.46
St.dev	0.33	0.33	0.25	0.29	0.36
		t= -7.2991		t=1.2540	
Minimum	0.03				
Maximum	1.25				

Soil fertility	Fertilizer adopter		
	Yes	No	Total
Fertile	64(65.98%)	66(61.68%)	130(63.73%)
Average/infertile	33(34.02%)	41(38.32%)	74(36.27%)
Total	97	107	
	Chi^2= 0.4064		

Source: own survey data, 2014

4.2.5. Education of household head

The education level of the sampled household head of the vegetable producers stretched from illiterate to diploma holders. The following table (4.2.5) revealed that the average household heads of schooling level of fertilizer adopters is 5.13 and their corresponding figure for non-adopters is 5.72. From the statistical analysis performed, it is found out that the mean education level difference between adopters and non-adopters of fertilizer is statistically not significant telling that education has no influence on the adoption decision.

To the other hand, the average household head education level of adopters of pesticides is 5.87, and the corresponding figure for non adopters is 5.08. From this statistical analysis, it is found out that the mean education level difference between the pesticide users and non-users is not statistically significance (table 4.2.5 bellow).

Table 4.2.5 Education level of respondents(both technologies)

Description	Sample HH	Chemical fertilizer		Pesticides	
		Adopter	Non adopter	Adopter	Non adopter
total	204	97	107	93	111
Mean	5.44	5.13	5.72	5.87	5.08
St.dev	4.06	3.73	4.33	4.55	3.57
		t= 1.0296		t= -1.3879	

Source: own survey data, 2014

4.2.6. Engagement activities of households

Urban agriculture provides informal employment to the urban unemployed and underemployed through work opportunities, which can be reduced on a part time or seasonal basis. Therefore, urban agriculture is one of the possible survival strategies for the urban poor, hence becoming one of the solutions to urban unemployment and underemployment. Besides, UA creates par-time work even for those who engaged in different activities. Therefore, the condition of permanent work matters whether to give full attention to the farming or not in such as technologies adoption, following up in the growing period, and so on. Having reflection this concern, the survey comes out with some evidence regarding additional engagement (off-farm activities). Accordingly, 130(65.69%) of the sample household have no additional work, so their main source of income is only farming, while 30(34.31%) households of the sample size have additional work in different activities. With both of the technologies(Fertilizer & pesticides), the chi-square test not significant. The chi-square test of FTA revealed that the mean difference between adopter and non adopters is statistically not significant but have positive relationship. In the PTA perspective, the mean difference between the two groups is statistically not significant too and have positive relationship(Table 4.2.6.1).

Table 4.2.6.1 engagement activities

Based on total sample hh (a)			Based on the technologies (b)			
			Fertilizers		Pesticides	
Off-far	Frequ	pect	adopter	Non-adopter	adopter	Non-adopter
			97	107	93	111
Yes	70	34.31	30(30.93)	40(37.38)	30(32.26)	40(36.04)
No	130	65.69	67(69.07)	67(62.62)	63(67.74)	71(63.96)
			chi2 = 0.9406		chi2 = 0.3204	

Source: own survey data, 2014

Concerning the activities they engaged in addition to urban farming is stated in the following table (4.2.6.2) by SPSS statistical tool.

Table 4.2.6.2 Participation in Off-farm Activities

Description		Frequency	Percent	Cumulative Percent
Valid	employed in public sector	11	5.4	24.4
	employed in private sector	13	6.4	53.3
	engaged in NGO	1	0.5	55.6
	engaged in daily labor	1	0.5	57.8
	engaged in masonry	3	1.5	64.4
	engaged in commerce	5	2.5	75.6
	renting house	3	1.5	82.2
	engaged in broker	2	1.0	86.7
	engaged in other activities	3	1.5	93.3
	employed in private sector and engaged in commerce	1	0.5	95.6
	employed in public sector and renting house	1	0.5	97.8
	engaged in commerce and renting house	1	0.5	100.0
	Total	45	22.1	
Missing	System	159	77.9	
Total		204	100.0	

Source: own survey data, 2014

Of the total 45(22.06%) who have additional activities, 5.4%, 6.4%, and 2.5%, are engaged in public sector employment, private sector employment, and engaged in trade respectively. Others have also engaged in more than one activity, as we can see on table 4.2.7.2 above.

4.2.7. Farming experience on vegetable growing

Farm experience helps the farmer to get more understanding of management practices of the farm activities. In relation to vegetable growing, as indicated in Table 4.2.8 below, there is statistically significant mean difference between adopters and non-adopters of fertilizer. The mean year of the respondents experience in vegetable growing for adopter and non-adopters of fertilizer is 6.09 and 4.88 years, respectively. And for the pesticide adopters and non adopters is 5.33 and 5.56 years, respectively. The result indicates that the mean years of vegetable growing experience of pesticide of both categories are nearly equal. Vegetable growing experience alone cannot draw the grower to adopt the pesticide technology(table 4.2.8 below).

Table 4.2.7 farming experience(vegetable growing)

Description	Sample HH	Chemical fertilizer		Pesticides	
		Adopter	Non adopter	Adopter	Non adopter
total	204	107	97	111	93
Mean	5.46	6.09	4.88	5.33	5.56
St.dev	4.317	5.06	3.43	4.40	4.26
t=value		t= -2.0211		t= 0.3703	
Minimum	2				
Maximum	21				

Source: own survey data, 2014

4.2.8. Nearness to Market from farm land

The mean distance to the market place in kilometer for the sample households is found to be 3.39 km with a minimum of 0.2 km and a maximum of 12 km. although they are working in UA, they have no market access; rather they have to travel within a maximum of 12 kilometers. The t-test was employed and the result of the mean difference was not significant for both technologies and positive relationship with fertilizer adoption but negative to pesticide technology.

Table 4.2.8 marker nearness from farm land

Description	Sample HH	Chemical fertilizer		Pesticides	
		Adopter	Non adopter	Adopter	Non adopter
total	204	97	107	93	111
Mean	3.39	3.22	3.56	3.46	3.34
St.dev	2.84	2.39	3.19	2.38	3.18
t=value		t = 0.8494		t = -0.3011	
Minimum	0.2				
Maximum	12				

Source: own survey data, 2014

4.2.9. Nearness of farm land from homesteads

The average distance between the grower's residence and farm land of the sample households is found to be 1.40km with a minimum of 0.002 km and a maximum 7 km distance.

According to the survey, the mean distance from homestead of the adopter's and non adopter's of fertilizer and non adopter of pesticide is less than 1.5 km. But of the adopter of pesticide it is little higher and is 1.566 km. All in all, the average distance of farm land to homestead is fair and less than 2 km. The t-test result of adopters and non-adopters of fertilizer depicted that, there was no significance difference, whereas, of the pesticide, it showed negative but significant relationship.

Table 4.2.9 nearness of farm land from home

Description	Sample HH	Chemical fertilizer		Pesticides	
		Adopter	Non adopter	Adopter	Non adopter
total	204	97	107	93	111
Mean	1.40	1.381	1.418	1.57	1.26
St.err	0.09	0.1289	0.1288	0.15	0.11
St.dev	1.30	1.269	1.332	1.46	1.13
t=value		t = 0.2016		t = -1.6721	
Minimum	0.002				
Maximum	7				

Source: own survey data, 2014

4.2.10. Farmers' Attitude towards pesticide technology

According the survey's data analyzed statistically, about 83.82% of vegetable growers of the sample have good attitude on pesticides, whereas about 16.18 % growers have no good attitude. From the total sample household, 93(45.59%) households have adopted pesticide last year and of them 96.77% have good attitude towards the pesticide. The result of chi-squere depicts that, there was a significance difference between adopters and non adopters on attitude of disease control chemicals.(table 4.2.10 below).

Table 4.2.10 respondent's attitude towards pesticides

	pesticide adopter		
Attitude to chemicals	Yes	No	Total
Good	90(96.77%)	81(72.97%)	171(83.82%)
Otherwise	3(3.23%)	30(27.03%)	33(16.18%)
Total	93(45.59%)	111(54.41%)	
	$Chi^2 = 21.1410$		

Source: computed from own survey data, 2014

4.2.11. Farmer's perception on chemical fertilizer

As indicated in table 4.2.11 below, about 92.78% of fertilizer adopters perceived the importance of fertilizer as good and the remaining 7.22 % have not good perception. From those farmers who do not adopt the chemical fertilizer about 32.71% of 107 respondents have good perception on it. But they don't used it due to many reasons such as high cost, availability of manure, etc. but the remaining of these none adopter do not have good perception on chemical fertilizer in general(the detail information is in table 4.2.11 below). The result of chi-squere depicts that, there was a significance difference between adoption and perception.

Table 4.2.11 Farmer's perception on Chemical fertilizer

	Fertilizer adopter		
Perception on chemical fertilizer	Yes	No	Total
Good	90(92.78%)	35(32.71%)	125(61.27%)
Otherwise	7(7.22%)	72(67.29%)	79(38.73%)
Total	97	107	
	$Chi^2 = 77.3767$		

Source: computed from own survey data, 2014

4.2.12. Access to credit service

The main source of credit in the study area is Dedebit microfinance. From the sample households 60.78 percent get credit while 39.22 per cent do not take credit due to various reasons. The comparison by adopting disclosed that 62.89 percent users and 37.11 percent non users take credit. The chi square test result revealed that the relationship between access to credit and adoption of fertilizer is statistically not significant.

The comparison of users of pesticide also disclosed that 28.0 per cent users and 72.0 percent non users take credit. The chi square test result (2.8622) revealed that the relationship between access to credit and using of pesticide is statistically significant.

Table 4.2.12.1 Access to credit service(pesticide)

		Chemical fertilizer		Pesticide	
Description	Sample hh	adopter	Non adopter	adopter	Non adopter
Yes	124(60.78%)	61(62.89%)	63(58.88%)	63(67.74%)	61(54.95%)
No	80(39.22%)	36(37.11%)	44(41.12%)	30(32.26%)	50(45.05%)
Total	204	97(47.55%)	107(52.45%)	93(45.59%)	111(54.41%)
		Chi^2=0.3429		Chi^2=3.4710	

Source: computed from own survey data, 2014

As we see in the following table(4.2.12.2), the main reason not borrowed money, which holds the highest frequency percent (46.6) is because they do not want to borrow. Moreover, this is also simply they may have enough money or because of the high interest rate or fear of investment risk. From the users 32.26 percent of the respondents and from the non user 45.05 percent households said that they don't want credit and the rest complained about high interest rate.

Table 4.2.12.2 Problems related to credit access

Description		Frequency	Percent	Cumulative Percent
Valid	Not available credit	6	2.9	3.8
	High interest rate	31	15.2	23.6
	I don't prefer to borrow	95	46.6	84.1
	Investment risk	22	10.8	98.1
	High interest rate, I don't want to borrow & investment risk	1	0.5	98.7
	High interest rate & I don't want to borrow	1	0.5	99.4
	I don't want to borrow & Investment risk	1	0.5	100.0
	Total	157	77.0	
Missing	System	47	23.0	
Total		204	100.0	

Source: computed from own survey data, 2014

4.2.13. Sufficiency to water for irrigation

According to the survey result, 43.14 percent of the sample households have the scarcity of water for irrigation and the rest 56.86 percent have no problem of water for irrigation at all. When we see the comparison by users and non users of fertilizer, 35.05% of users and 50.47% of non user have replied that they do have problem of scarcity of water for their vegetables whereas the rest replied no problem. The chi square test showed that there is relationship between adopting fertilizer and water for irrigation.

Table 4.2.13 Access to water for irrigation(fertilizer)

Description	Sample HH	Adopter	Non-adopter	chi^2
Scarcity	88(43.14%)	34(35.05%)	54(50.47%)	4.9292
sufficiency	116(56.86%)	63(64.95%)	53(49.53%)	
Total	204	97	107	

Source: computed from own survey, 2014.

4.2.14. Access to extension service

The study shows that, 93.63 percent of the sample households get extension service. When we compare adopter and non adopter of fertilizer of the sample households, majority of the adopters get support from extension agents when compared to non adopters. According to table 4.2.16.1, 97.94 percents of adopters and 89.72 percent of non adopters get extension service. Extension service here refers training on application of Fertilizer, Pesticide, Manure, and other appropriate advices. In general, 95 adopters and 96 non adopters get extension services concerning the chemical application and other advices, such as on field training whenever they need technical advice related with vegetable farming activity. From the respondent 2.06 percent of the adopters and 10.28 percents of non adopters reply they do not get extension service. The chi square test indicated that there is significant relationship between adopting and access to extension service.

Table 4.2.14 Access to extension service

		Chemical fertilizer		Pesticide	
Description	Sample HH	adopter	Non-adopter	adopter	Non-adopter
Yes	191(93.63%)	95(97.94%)	96(89.72%)	92(98.92%)	99(89.19%)
No	13(6.37%)	2(2.06%)	11(10.28%)	1(1.08%)	12(10.81%)
Total	204	97	107	93	111
		Chi^2=5.7596		Chi^2=8.0386	

Source: computed from own survey, 2014

Table 4.2.14 illustrates of households of adopters and non adopter of pesticides. Majority of the adopter households get support from extension agents when compared to non adopters. According to the survey 98.92 percents of users and 89.19 percent of non users of pesticide get extension service. Here the extension service is similar to the adopter of fertilizers, which refers to training on application of chemicals Pesticide, and giving other appropriate advices. From the adopter 92 and from the non adopter 99 households have got extension services. But 1.08 users and 10.81 non user households responds they do not get any extension services. The chi square test also indicated that there is significant relationship between adopting of pesticides and access to extension service.

4.2.15. Most often grown vegetable crops in the city

There are a number of vegetables that often grow in the city by vegetable growers. They might be selected either due to their relatively short time to harvest, resistance to the weather change, and their important value in the market. Table

4.2.15 depicted that the first ranked vegetables that are grown often is 'kusta', which accounts 57.8%. The second ranked is 'tomato' that ranked 48.5% and the third ones are 'potato' and 'cabbage' which accounts 31.4% each.

Table 4.2.15 often grown vegetables in the city

vegetable types	frequency	percent
onion	58	28.4
potato	64	31.4
green pepper	13	6.4
hot pepper	27	13.2
carrot	49	24.0
tomato	99	48.5
cabbage	64	31.4
Garlic	23	11.3
Sweet potato	9	4.4
Beetroot	24	11.8
Lettuce	5	2.5
Salad	71	34.8
Cauliflower	0	0
'Kusta'	118	57.8

Source: computed from own survey, 2014.

4.2.16. Major problems encountered on adoption of the technologies

The significance of fertilizer and pesticide technologies in yield raising and make healthy product is unquestionable. Having this benefit under consideration, the government is working its best effort in supplying and creating awareness in the growers. But there are major problems which mentioned by the sampled respondents during the survey. These issues are depicted in table 4.2.18. based on the result of the survey, the first and second problems are 'high cost of chemical fertilizer' (84.8%) and high cost of pesticide(63.2%), respectively(table 4.2.18).

Table 4.2.16 major faced problems on adoption of the technologies

Problem on adoption	Frequency	percent
High cost of pesticide	129	63.2
Lack of pesticide supply	62	30.4
High cost of chemical fertilizer	173	84.8
Lack of fertilizer supply	21	10.3
Lack of credit accessibility	30	14.7
Lack of agricultural input supply	40	19.6
Lack of know-how to use the chemical technologies	15	7.4
Shortage of irrigation water	49	24
Shortage of agricultural farm land	80	39.2
Lack of technical support	9	4.4
Shortage of labor	6	2.9
Lack of farm experience on vegetable cultivation	16	7.8

Source: computed from own survey, 2014

4.2.17. Comparison of income from vegetable sales

One of the main objectives of this study is to check whether the adoption of the technologies (fertilizers and/or pesticides) leads to higher income of the vegetable growers. Accordingly, the total sample households (204) are categorized in to three treatment group, namely "both adopter" (=treated) and the rest otherwise (=untreated); "fertilizer only adopter" (=treated) and the remaining otherwise (=untreated); and "pesticide adopter" (=treated) and the rest otherwise (=untreated) (table 4.2.17).

Table. 4.2.17 Frequency of adoption of fertilizer and pesticide

		Pesticide		
		Non-adopter	Adopter	Total
Fertilizer	Non-adopter	58	49	107
	Adopter	53	44	97
	Total	111	93	204

Source: computed from own survey, 2014.

Table 4.2.17 showed that only fertilizer adopter households were 53, pesticide only adopter householders were 49, those who adopt all kind of technology were 44 households and those who do not adopt any technology at all were 58 households. Having this information, we can make three comparisons with regard to financial gain. Table 4.2.18 shows the result of comparison of the financial gain for all groups (adopter and non-adopters).

Table 4.2.18 Comparison of financial gain from sales of vegetable produces

Variables	Obs	Mean	t=test
1. Both chemical adopter			
Yes	44	36925.57	-7.4522
No	160	22553.41	
Diff=mean(yes)-mean(no)		14372.16	
2. Fertilizer only adopter			
yes	53	27880.69	-1.4814
no	151	24871.49	
Diff=mean(yes)-mean(no)		3009.202	
3.Pesticide only Adopter			
yes	49	27514.16	-1.1722
no	155	25065.01	
Diff=mean(yes)-mean(no)		2449.15	

Source: computed from own survey, 2014.

The income those who adopt both types of chemicals was exceeded by birr 14,372.16 from those none adopter at all or who adopted either one type.

4.3. Econometric Analysis

This section presents and discusses results obtained from heckman two-stage and ordinary least square (OLS) econometric analysis. The study has given attention to address the three specific objectives. The first objective is *to identify and single out the most influential factors that determine the likelihood of fertilizer and pesticide adoption*, the second objective is *to investigate the level of using (intensity) of fertilizer and pesticide of the city vegetable grower* households and the final one is *to assess whether the adoption of the technologies (fertilizers and pesticides) leads to higher income of the vegetable growers*.

4.3.1. Detecting multicollinearity and outliers

Before starting analysis, *multicollinearity* and *hetrokedaccity* tests were done to check the association among the variables. One of the assumptions of the multiple regression models is that there is no perfect linear relationship between any of the independent variables in the model. If such a linear relationship does keep going, we say that the independent variables are *"perfectly collinear,"* or that *"perfect collinearity"* is present. Perfect collinearity is easy to ascertain because it will be impossible to calculate the estimates of the parameters. In practice the more difficult problem is having a high degree of *"multicollinearity."* The variance inflation factors (VIF), the condition index (CI) and contingency coefficient (CC) are the most important tests to detect "multicollinearity" (Pindyck and Rubinfeld, 1991).

The presence of heteroscedasticity is detected by using the Brush Pagan test. This problem is addressed by calculating the robust standard error for the probit regression model. VIF also shows how the variance of an estimator is inflated by the presence of multicollinearity (Gujarati, 2003)

The study used the VIF to check for multicollinearity coefficient among the *continuous* variables and contingency coefficient (CC) was used to check multicollinearity among *discrete* variables. Studenmund (2006) has put a rule of thumb that multicollinearity is a serious problem when the correlation coefficient becomes 0.8 or above. Accordingly, no serious problem was noticed. In addition to this, *link test, normality,* and *endogeneity* tests have done for both heckman and ordinary least squares models where the test is found appropriate. Their results also show no serious problem at all. All test results are attached at the appendix parts.

4.3.2. Econometrics model of Impact Analysis (Heckman two-stage Model)

The econometric analysis for the Heckman two-stage procedure was performed using STATA version 12. The data were collected on 204 observations from Mekelle city (MC). There are different methods of impact evaluation of various program interventions among the adopter and non-adopter groups. However, for this study, we use the Heckman two stage methods to compute whether adopting those technologies leads to higher income of the adopters comparing to the non-adopters.

The Heckman two-stage procedure was employed in order to control the *selectivity bias* and *endogeneity* problem and to obtain consistent and unbiased estimates. The Heckman model in the first stage predicts the probability of adopting fertilizer and pesticide of each household, in the second stage it analyses the determinants of adoption of the technologies and the income difference between adopter and non-adopter groups.

4.3.3. Factors affecting technology adoption decision (Estimation result of the Binary Probit model)

In this sub section, we treat results concerning fertilizer and pesticide adoption at household level as well as the socio economic, demographic and other factors that affect the adoption behavior of vegetable growers. We used probit model of estimation to figure out factors having a certain sort of relationship to the technology adoption. The result for the Probit /adoption/ equation of FERTILIZER shows that *eight* out of eighteen variables *had* significantly influenced the probability of fertilizer adoption decision. These are farming experience of the household head(*fmexp*), cost of fertilizer(*costfert*), perception of the household head to chemical fertilizer(*percfert*), closeness of farm land to homesteads(disfarm), access to credit(*credit*), farm size(farmsize), off-farm activities(offfarm), and purpose of vegetable producing (*gofarm*). Whereas, PESTICIDE technology was found significantly influenced by *ten* out of variables like age of household head (*hhage*), education level of household head(*educ*), household sex(*gender*), farming experience of the household head(*fmexp*), closeness of farm land to homestead(*disfarm*), access to extension service (*extsuppo*), used farm size(*farmsize*), scarcity of irrigation water(*scarwat*), cost of pesticide(*costpest*), and attitude towards the pesticide(*attipest*). Factors that affect JOINTLY adoption for those who adopt both chemicals are like education level of the household head(*educ*) household size(*hhsize*), perception of the household head to chemical fertilizer(*percfert*), soil fertility(*fertility*), nearness of market center to the farm land(dismkt), farm size(farmsize), household income(hhincome), and cost of pesticide(*costpest*). This is shown on table 4.3.19 below.

Table 4.3.19 Estimation result of the Binary Probit model of the Technologies

Variables	Fertilizer		Pesticide		Joint(Fert.& Pest.)	
	Coeffi	p-value	Coeffi	p-value	Coeffi	p-value
constant	-3.181**	0.008	-2.474	0.149	-3.200**	0.018
hhage	.010	0.455	-.039**	0.007	.0222	0.101
educ	-.003	0.923	.143***	0.000	-.084**	0.026
gender	.132	0.764	1.380**	0.022	444	0.337
hhsize	.007	0.931	-.022	0.812	.193**	0.035
fmexp	.090**	0.004	-.095**	0.017	.026	0.469
costfert	-.677**	0.044	-----	-----	.036	0.915
percfert	1.067**	0.004	-----	-----	1.52***	0.000
manur	-.168	0.795	-.979	0.177	-.664	0.270
fertility	.403	0.193	.634	0.136	-.766**	0.013
disfarm	-.211**	0.047	.541**	0.001	.087	0.470
dismkt	-.055	0.381	.007	0.888	.087*	0.090
extsuppo	.215	0.600	1.493**	0.015	.026	0.951
credit	-.817**	0.009	.208	0.474	.295	0.297
farmsize	2.246***	0.000	-1.903**	0.002	-1.024*	0.052
scarwat	-.205	0.461	.522*	0.051	-.427	0.142
offfarm	-.741**	0.009	.244	0.421	.073	0.795
gofarm	.907**	0.064	.301	0.446	-.387	0.378
hhicome	1.64	0.568	-2.80	0.432	7.32**	0.013
costpest	----	-----	-1.032***	0.000	-1.004***	0.000
attipest	----	-----	1.088**	0.023	.651	0.155
Dependent variable	**Fertilizer adoption (fertadop)**		**pesticide adoption (pestadop)**		**Both adopter (bothado)**	
Number of obs	204		204		204	
LR chi2(18)	101.70		LR chi2(18)= 91.96		LR chi2(20) = 78.07	
(Prob > chi2)	0.0000		0.0000		0.0000	
Pseudo R2	0.4351		0.4088		0.3670	
_hatsq	0.297		0.376		0.585	
➔ Level of significance Sign: *-at 10 percent, **- at 5 percent, & ***- at 1 percent						

Source: computed from own survey, 2014.

Age of Household head (hhage): The role of a framer's age in explaining technology adoption is somewhat controversial in the literature. As farmer's age increase probability of adoption is expected to decrease (Techane,2006). Younger farmers were more likely to adopt and the effect of age on the probability of adoption was elastic (Hailu, 2008). Farmers who have experience use higher rate of fertilizer as older farmers may build up more experiences than the younger ones. In the other way, when farmers getting older they are tending to be conservative and more risk averse. In the case of these two points of view, age was hypothesized as undecided (positive/negative). Here, when we see age according to the two technologies, i.e., fertilizer and pesticide, in the fertilizer part, the probit result shows, this variable has *positive sign but not significant*. However, in the case of pesticide it is *negatively correlated at 5 percent of significant level*. This implies, when the household head is getting older and older, he/she becomes conservative, and he might allot additional time to care his farms preferring prevention.

Household head education leve(educ): The coefficient of *education* variable is *significant at 1% for the pesticide adopters with positive sign*. The positive sign indicating that the variable to be an important determinant of pesticide adoption and has with the expected positive sign. The implication of this result is that educated household head, the primary decision maker, is more capable of accessing and understanding information about the use of pesticide, its return, and the risks of not adopting it. This result fits with the findings of Holden et al., (2008) in Ethiopia. Whereas, to the joint adoption, it is *negatively and significantly correlated at 5% adoption probability level*. To the contrary of Holden et al., (2008) finding, this negative sign indicates that educated farmers are more likely to be aware of the negative effects of the technologies.

In the same assessment, education to fertilizer use was found negatively related with no impact, which totally out of the expectation of the study and other related literatures. When we see this situation critically according to the modern world, education and using of fertilizer seems have negative relationship, i.e., negative as inorganic fertilizer have negative consequences to human health and environment. So the true logic behind this relationship is as the household advances in education, he becomes more concerned about the negative side effect of fertilizer, as it is inorganic, deciding to leave using it.

Sex of household head(gender): Just looking at table 19, one can figure out that male headed households seems relevant to the adoption of fertilizer but it is not significant. However, in the *pesticide male headed was positive adopters at 5 % significant level of adoption*. This result is consistent with the findings of Tadesse (2009). But in the case of joint adoption, gender indicates nothing but it is with positive sign.

Household size(hhsize): The other determinant variable in the regression coefficient analysis is family size. Family size in the study is considered as the number of individuals who resides in the respondent's house. Large family size is assumed as an indicator of labor availability in the family. The total number of family members in a household is important for availability of economically active labor. It is obvious that some new technologies are relatively labor saving and others are labor using(Teame, 2010). For those labor using technologies just like fertilizer adoption, labor availability plays major role in adoption. To the contrary of this explanation, the result of this study indicates that household size with regard to the likelihood of pesticide adoption, it is negatively correlated but not significant to the adoption of either to fertilizer or pesticide. However, family size was found positively correlated at 5% level of significance to the joint adoption decision. This result matches with the findings of Feder et al., (1985) which have figured out as new technologies increase the seasonal demand for labor; but different in the case of individual technology adoption decision. The possible justification for negative and insignificant situation for the adoption of fertilizer and pesticide is that the more family size the household has the more used man-power such as for weeding for the pesticide and the application of manure for the fertilizer.

Farming experience on vegetable growing(Fmexp): Farmers with higher experience of cultivation appear to have often full information and better knowledge and are able to evaluate the advantage of the technology (Chilot 1994). It is believed that economic agents; in this case, farmers resist to accept and adopt a new technology at its early stage. This is true for the joint adoption of the finding of this study, which is found positive relation and not significant. However, as time goes through, learning skills and experiences enable them to become willing and open to accept and practice the technology at the grass roots level. Rahman (2007) was strengthened this idea. He said that "Experienced farmers are assumed to have tried out a number of profitable technologies as experience helps an individual to think in a better way and makes a person more mature to take right decision." In this study, *farming experience* was found positively related and significant at 5% to fertilizer adoption. However, in the case of pesticide, this hypothesis was not found true. It is found that have negative correlation but significant at 5% significant level. Here the two technologies have different correlation with farming experience. This seems contradicting the hypothesis that was proved true in relation of farming experience and fertilizer adoption decision.

Cost of the technology(Costfert/costpest): The cost of agricultural inputs may encourage/discourage farmers in order to use production enhancing inputs. If the cost of inputs does not appreciate by the farmers, it will have negative effect on technology adoption. Here cost refers to the value of fertilizer and pesticides technologies in terms of money. Therefore, the cost of fertilizer has negative relation to fertilizer adoption at 5% significant level as expected. The cost of pesticide affects pesticide adoption and joint adoption at 1% significant level and has negative correlation as predicted. In all cases, the result consist with finding of Wolday (1999). But for the join adoption decision, the cost of fertilizer was found positively correlate but not significance.

Farmer's perception on Fertilizer using (percfert): The pace of adoption is affected by the farmers` perception of the characteristics of the innovation (Ban and Hawkins, 1996). The result of this study reveals that vegetable growers who had positive perception of the technology, adopted more fertilizer. This finding is supported by Shiferaw and Holden (1998) who found that perception influences adoption positively. This variable also showed a positive relationship with adoption of chemical Fertilizer and the joint technologies adopters. Moreover, it is significant at 5 percent probability level for the fertilizer adoption but significant at 1 percent to the joint adoption. The possible justification for the positive relationship is that farmers in the study who have good perception (attitude) towards chemical fertilizer are willing to adopt it and practically they are using it despite its high cost and the presence of environmental threats.

Attitude towards pesticides (attipest): this variable showed a positive relationship with adoption of pesticide and it is significant at 5 percent probability level of adoption. The possible reason for the positive connection may indicate that in the study area, those households who had a good attitude on pesticide have used pesticide. However, it is not significant for the joint adoption of both technologies(fertilizer and pesticide) though it showed positive sign.

Soil fertility (fertility): has negative relationship rather with the joint adoption of fertilizer and pesticide. That means, when the fertility of the soil increase the level of fertilizer and pesticide jointly adoption decreases. The result matches with the finding of Kouame (2011) in general. To the contrary, the level of adoption of fertilizer was neither significant nor negative in relation to the soil fertility.

Closeness farm land to the homesteads(disfarm): in this study, the variable closeness of farm land to homesteads has *positive correlation and significantly at 5% to the adoption of pesticide.* This means, the more nearer farm land to homesteads gets more attention and follow-ups than that at distance farm land. The result matches with the finding of Teame (2011). However, though it is not significant it has also positive sign to the jointly adoption of the technologies. But to the contrary, for the fertilizer adoption it has *negative sign with significance at 5% significance level of adoption*. The possible reason for this might be, the nearer farm land gets more manure, which can be a substitute to the chemical fertilizer.

Nearness of market center to farm land (dismkt): Area with good market access represents expectation of greatest potential for agricultural development. In areas closer to market, growing of higher value crops and high level of use of external input is expected. Better access increases the local prices of crops and promotes more intensive use of inputs. In this study, this variable was found *positively related and have significant at 10 percent probability level in joint technologies adoption*. The result matches with the finding of Teame (2011). This positive and significant coefficient of nearness reveals that households nearer to the market center encouraged getting high vegetable production. This means, if the farm land located near to market, the households tend to buy agricultural inputs as they can have easy access to sell their produces in the market. But this variable is not significant to the fertilizer and pesticide adoption with negative sign to the fertilizer and with positive sign to the pesticide.

Support of Extension agents(Extsupp): it is widely accepted that agricultural extension services play an essential role in the motivation of farmers towards the adoption decision of new technology by rising the stock of information related to modern production growth more frequently and easily (Feder, 1985). This might increase their agricultural output and productivity. Phoebe et al. (2000) also found that exposure of the farmers to extension services and their access to up to date farm information increased the probability to adopt new technology. The result of this survey revealed that access to extension services *influences pesticide uses positively at 5 percent.* But to the fertilizer and joint adoption, it has positive sign but not significant at all levels which is different from the above mentioned literatures.

Access to credit (credit): many have been said about credit and adoption of technologies as follows. Farmers without cash and no access to credit will find it very difficult to attain and adopt new technologies (Million and Bellay, 2004). This idea was also supported by Feder *et al.*, (1985) as credit programs may enable farmers to purchase inputs or acquire physical capital, needed for technology adoption. In other words, the availability of credit facilitates technology adoption. In this study, access to credit service was found significant at 5 percent for fertilizer adoption but with negative sign. To the contrary, access to credit was found positive sign but not significant to the adoption of pesticide and the joint adoption decision. According to the reply of the respondents that indicated in the statistical descriptive above, the three possible reasons which have high percentage are either they don’t want to borrow (90% responded) due to different reasons, or because of the high interest(31%), or they fear investment risk(22% of the respondents).

Farm Plot size(farmsize): The vegetable growers, who have large sized plot of land/backyard/ have more chances to adopt technology. Farm size determines households' decision to adopt or to reject new technologies. Farm size can be positively related to adoption because farmers can experiment with new technologies on portion of land without severely risking their minimum subsistence food requirement. Therefore, in this study, plot size was found with *positively relation and significantly related at 1 % probability level likelihood of adopting fertilizer* which consist with the finding of Zhou, (2010) and negative relation and at 5 % significant level to the pesticide and also with negative sign but significant at 10% to the joint adoption. In the area of fertilizer adoption, size of farm land stands as the highest of the adoption decision factors. The negative sign of farm size with pesticide and joint technologies adoption may cause due to high cost to cover the whole area affects to use it. This means as farm size increase, the probability of adopting pesticide is decrease because the larger land needs high amount, which in turn needs high cost to buy it.

Scarcity of water for irrigation (scarwat): this variable has come out to be significant at 1% and positively influenced on the pesticide adoption of the households. But to the fertilizer and joint adoption, it is negatively correlated as expected but not significant. The finding of this study shows that scarce to irrigation water has a statistically significant influence in explaining the adoption decision. Respondents who have scarce irrigation water have lesser probability to adopt fertilizer and high probability of adoption to the pesticide technology. This may because of unsafe water might cause water born diseases.

Engagement in off-farm activities(offfarm): this variable is found significant at 5% of significant level fertilizer adoption with the expected negative sign and this result matches with the finding of Teressa, (1997). This implies that farmers who engaged out of farm activities, they do not involve fully to farming activities consequently, buy fertilizer or other inputs might be considered as unwanted cost. This variable shows positive correlation but not significant to the adoption of pesticide and joint adoption decision.

Purpose of farming(gofarm): this variable was positively correlated at 10% significant level for the fertilizer adoption and this result consists of with the finding of Zhou, (2010). If vegetables are grown for market purpose, farmers adopt fertilizer to use in their farm land. Because they need to earn more profit from their sale believing that using fertilizer gives high yields.

Household income: this variable is another possible determinant factor of adoption agricultural technologies. The same to this, this was found with positive sign and significant at 5% significant level for the joint technologies adoption which matches with the finding of Tadesse, (2009). But in the fertilizer and pesticide, it was not significant and has different sign of correlation.

In this analysis we have seen factors that affect adoption decision of the two chemical technologies separately and jointly. From the 18 total explanatory variables that hypothesized to influence fertilizer adoption, eight variables were found significantly influenced the probability of adoption decision. Furthermore, out of the 18 total explanatory variables, which are hypothesized to affect pesticide technology adoption decision, ten variables were found significantly affected the probability of adoption decision to pesticide. Likewise, from the 20 explanatory variables that hypothesized to influence joint adoption, eight of them were found determinants of the joint technology(fertilizer and pesticide) adoption decision. This fact is shown in table 19 above with respect to fertilizer and pesticide, and joint adoption.

Here in the adoption equation _hatsqs were found not significant in all cases, which can be to say that the model is correctly specified (table 19).

4.3.4. Factors affecting financial gain from sale of vegetables-Heckman Outcome model

The technology adoption has estimated according to the model put in the methodology part .We note that the dependent variable of the model if this part is effect of income gain from sale of vegetables of the technology adopters. Hence, the regression coefficients measures the unit income change in vegetable production for a unit change in the explanatory variable. In most cases, the statistical significance of the various parameters differs widely across variables and the signs of the most estimated variables are as expected. As it can be seen on tables 4.21 and 4.22, from the results of the different regression models some are statistically significant at 1%, 5% and 10% level while others are not significant even at 10% level of significance.

In the selection /outcome/ equation of the model, five and three variables were found to be a significantly determinant of household technology adoption of fertilizer and pesticide, respectively. These are: household size, farmer's farming experience on vegetable cultivation, farmers' perception on chemical fertilizer, off-farm activities, and household income in the fertilizer perspective and farmer's farming experience on vegetable cultivation, household income, and cost of pesticide were the determinants in pesticide manner. In the case of joint adoption, farmer's farming experience on vegetable cultivation, farmers' perception on chemical fertilizer, household income, and cost of pesticide were the determinants. Table 4.3.20 depicted this evidence.

Table 4.3.20 Estimation result of the outcome Equation model

Variables	Fertilizer		Pesticide		joint adoption(Fert.&Pest)	
	Coeffi.	p-value	Coeffi.	p-value	Coeffi.	p-value
constant	7520.186	0.360	10071.55	0.201	10056.43	0.197
hhage	-20.023	0.802	2.054	0.980	-30.326	0.701
educ	-84.268	0.625	-143.675	0.408	-102.340	0.560
gender	5028.885	0.145	3446.044	0.297	4714.889	0.174
hhsize	869.023*	0.090	783.327	0.132	814.516	0.102
fmexp	555.248**	0.035	621.478**	0.027	596.403**	0.027
costfert	1883.587	0.359	---	---	1559.956	0.453
precfert	4767.085**	0.022	---	---	4663.22**	0.026
manur	-6694.332	0.149	-4119.127	0.325	-5990.568	0.175
fertility	-691.4048	0.644	-320.458	0.833	-189.76	0.898
disfarm	755.5092	0.390	480.725	0.585	573.466	0.503
dismkt	186.1676	0.518	227.577	0.469	259.925	0.380
extsuppo	3147.715	0.207	2768.771	0.238	2643.061	0.275
credit	1064.585	0.531	132.6894	0.940	192.187	0.913
farmsize	-697.6207	0.846	2530.268	0.414	101.523	0.977
scarwat	-2472.138	0.130	-2347.189	0.139	-2440.802	0.132
offfarm	-3115.923*	0.066	-2245.975	0.181	-2516.265	0.135
gofarm	740.9825	0.787	807.895	0.763	542.714	0.838
hhincome	.1098185**	0.010	.112**	0.012	.1046**	0.017
costpest	----	----	-3527.749**	0.043	-3585.793**	0.037
attipest	----	----	1512.706	0.548	682.118	0.787
invmill	741.7037	0.093	75.874	0.265	-.4712	0.996
Dependent variable	Sales income from Fertilizer adoption		Sales income from pesticide adoption		joint technology adopter	
Selection rule	fertadop=1		Pestadop=1		Bothado=1	
Number of obs	204		204		204	
F(19, 184)	6.38		F(19, 184) = 4.99		F(21, 182) = 4.71	
Prob > F	0.0000		0.0000		0.0000	
R-squared	0.3541		0.3455		0.3663	
Root MSE	10772		10843		10729	
-Level of significance Sign: *-at 10 percent, **- at 5 percent, & ***- at 1 percent						

Source: computed from own survey, 2014.

According to the summarized model results shown in the above table possible explanation for each significant independent variable is given as follows.

Family size(hhsize): this variable shows positive sign and significant at 10 percent significant level to fertilizer adopter farmers. The positive sign indicated that as the working labor of the household increases by one person, the income of the household increase by birr 869.023 for the fertilizer adopter households. But in the case of pesticide and joint adopter, family size shows positive relationship, it is not significant at all levels.

Farmer's farming experience on vegetable cultivation (fmexp): this variable was positively correlated in all situations at 5% significant level. The positive and significant coefficient of farm experience reveals those households who have more farming experience have higher vegetable production. The possible justification for the positive relationship may indicate that in the study area, those households who have better experience assumed to have tried out a number of profitable technologies as experience helps an individual to think in a better way and makes a person more mature to take right decision. Thereby, they can get improve vegetable production. The coefficient of the variables indicates that as the household have better experience by one year vegetable production of the household increases by birr 555.248 for the fertilizer adopter, by birr 621.478 for the pesticide adopter, and by 596.403 for the joint or both technologies adopter. This result is consistent with the finding of Rahman, (2007) and Chilot, (1994) in the two technologies aspects.

Cost of pesticide: The cost of pesticide has negative sign and significant at 5% to both pesticide and joint adopters of vegetable growers. This implies when price increases by 5% the income of the growers will decrease by birr 3527.75 and 3585.79 for the pesticide adopters and joint technology adopters, respectively.

Perception of farmers on fertilizer(percfert): this variable is positive and significant at 5% significant level. The positive sign indicates that those who have good perception able to buy and enable to increase their income by birr 4767.08 and by birr 4663.22 for the fertilizer adopters and joint adopter farmers.

Participation in off-farm activities(offfarm): this variable correlated with fertilizer adoption at 10%. This negative sign indicated that as a farmer participated in other activities, his income can decrease by birr 3115.92 because he couldn't give enough follow up to his larms.

Household income: this variable is statistically significant at 1 percent probability level and has positive relationship for all the three group of adopters. The result indicated that income of household increase, its future income will increase by birr 0.110, 0.112, and 0. 104 for the fertilizer, pesticide and joint(both) adopters, respectively.

Here, the *Inverse Mills ratio* was found significant to the fertilizer adopters but it is at 10% significant level which is above the set degree of variability (5%) therefore, this does not indicate selectivity bias. And the positively sign of the inverse mills ratio also suggests that the error terms in the adoption and outcome equations are positively correlated. This shows that those unobserved factors that make the household adopter in using fertilizer are likely to be positively associated with household vegetable production. In the case of pesticide and joint adopter, the mills ratio is not significant at all levels but with negative correlation to joint adopters. When it is not significant it indicates there is no selection bias and the negative sign implies that unobserved factors, which make to adopt both technologies together, are negatively correlated to technology adoption.

As indicated in table(4.3.21) Heckman two stage outcome results revealed that the adopters group households have on average ETB 25,653.29 more than the non-adopters group in income difference of vegetable sales because of adoption of the technologies separately as well as jointly. The reason for having better income difference is farmers using the technologies get more vegetable sales income difference. Finally the overall evaluation of the study presented that by the adoption, the treated groups are in better position than the control group. This implies adoption of technologies like fertilizer and pesticide has significant effect on income of vegetable sales of adoption as compared to the non-adopters. Besides, the mean difference among the three adopter groups is similar. This may be because of that they almost do not have significant difference in their number i.e., 44, 49, and 53 households for joint, pesticide, and fertilizer adopters, respectively. But when we see the difference between the minimum and maximum, it has as such significant difference.

Table 4.3.21 Mean difference of income difference from vegetable sales of adopters

income difference from sales	obs	Mean	Sta. dev.	min	max
Income difference from fertilizer adopter only	204	25,653.29	7593.435	10,782.93	56,297.24
Income difference from pesticide adopter only	204	25,653.29	7500.89	8,707.827	58,310.89
Income difference from both chemical adopters	204	25,653.29	7,722.83	10,133.97	57824.45

Source: computed from own survey, 2014.

4.3.5. Factors affecting the intensity of fertilizer and volume of pesticide consumption

In determining the relationship of factors that affect the intensity/volume of fertilizer/pesticide materials used, a linear regression model was used. Prior to running the OLS regression analysis explanatory variables were checked for the existence of endogeneity. In this research, in order to minimize or to avoid the existence of endogeneity robust standard errors was used.

Table 4.3.22 gives the parameter estimates of the intensity of fertilizer and volume of pesticide applications. We find that variables like household head education level(educ), household sex(gender), household size(hhsize), cost of fertilizer(costfert), farm land distance/nearness/ from market center(dismkt), extension support(extsuppo), and farm land size(farmsize) are the most important determinants of the level of demand for fertilizer in vegetable farming.

In the case of pesticide, these thought to influence the volume of pesticides were used. The volume of pesticides used (the dependent variable) was measured by the actual expenditures in 2013. The independent variables considered were age of household head(*hhage*), household head education level(educ), sex of household head(*gender*), and household size(*hhsize*) were the most determinant factors that affect the volume of use. For more information we can see table 4.3.22 and the explanation underneath it.

Table 4.3.22 Ordinary Least Squares estimation results of intensity/volume of use

Variables	Fertilizer			Pesticide		
	Coeffic.	Robust Std. Err	p-value	Coeffic.	Robust Std. Err	p-value
Constant	.044	.477	0.928	5.351**	1.615	0.002
hhage	-.002	.004	0.657	-.025*	.012	0.056
Educ	.035**	.015	0.027	.088**	.037	0.024
Gender	.388**	.142	0.010	-1.595**	.437	0.001
Hhsize	-.199**	.070	0.008	-.256*	.131	0.060
Fmexp	.018	.011	0.100	-.067	.048	0.168
Costfert	-.126*	.064	0.059	----	----	----
percfert	-.086	.243	0.727	----	----	----
costpest	----	----	----	-.088	.309	0.776
attipest	----	----	----	-.139	.707	0.845
Manu	.021	.220	0.925	-.305	.371	0.417
Fertility	.122	.082	0.147	.222	.262	0.403
disfarm	-.055	.049	0.271	.187	.153	0.232
Dismkt	.175***	.033	0.000	.023	.110	0.836
Extsuppo	.361**	.127	0.008	----	----	----
Credit	.189	.160	0.247	-.136	.324	0.678
Farmsize	2.412***	.181	0.000	-.240	.848	0.779
offfarm	.018	.078	0.823	.557	.331	0.102
scarwat	.073	.079	0.364	-.143	.246	0.566
Hhincome	-9.41	1.39	0.502	-2.37	6.92	0.734
gofarm	-.141	.098	0.160	.381	.292	0.203
Obser.= 53 F(19,34)= 58.23 Prob > F =0.0000		R2 =0.9210 Root MSE=.23749		Num.of obs= 49 F(17,31)= 7.60 Prob>F= 0.0000	R2 = 0.6554 Root MSE=.74365	
***, **, * = significant at 1%, 5% and 10%, respectively						

Source: computed from own survey, 2014

Farmers' *household head age* result is important when the volume of use of pesticide application is considered. Being an *experienced farmers' on vegetable growing* has been found to affect negatively the volume of use of pesticide. This variable has statistically significant effect at 10% level, but with negative sign. This finding confirms that as age increases the volume use of pesticide decreases.

Educational level of household head is important in both case of use and has effect at 5% significant level with positive sign. This variable assures that as education and intensity/volume of use fertilizer and pesticide, respectively have positive relationship.

Gender is another important factor that affects the intensity use of fertilizer and pesticide at 5% significant level. This variable is correlated positively to fertilizer but negative to pesticide. When the positive sign to fertilizer use implies male headed households have better opportunity in using more amount of fertilizer but to the pesticide it has the opposite implication, i.e., female headed household has better opportunity in using pesticide in hectares. The results also reveal that household *size* is negatively related to the application rate of fertilizer and pesticide at 5% significant level. This variable has different sign from the predicted sign.

Like to the adoption equation, the *cost of fertilizer* has been found to affect the intensity of fertilizer application negatively but at 10% significant level. This result suggests that farmers' perception about the cost of fertilizer is an important determinant of fertilizer intensity of use.

Though this study has been conducted in urban area, nearness to market was found very determinant factor for the intensity use of fertilizer. The distant farm land to the market center affects the intensity of use of fertilizer as it gets less follow up and attentions. This variable has positive effect to the fertilizer intensity of use at 1% significant level. This positive sign indicates that as the nearness of farm land to market center increases by a unit, the intensity of use of fertilizer increases by about 0.175 percentages point.

Extension support was another important variable for the intensity of use of fertilizer. This variable has positive sign at 5% significant level.

Farm size is also another important variable that is positively related to the application rate of fertilizer use of intensity. In the case of fertilizer of use, this is a predictable sign as a large farm size can be considered as a wealth indicator for the farmer. Therefore, for a farmer who has already adopted fertilizer as a farm input, an increase on his level of wealth would result in an increase in the rate of fertilizer application. When farm size increases by one unit, its use of intensity increases by 2.41 percentages point. But this seems contradict for the logic of intensity and cost.

In general this study is unique for itself (as it is for the first time for the context of the topic) as well as comparing to the rural agriculture in relation to technology adoption as urban farming has complex nature. This study deals on farm technology adoption in urban farming in general, in vegetable growing in particular. Moreover, it addressed the determinant factors for the adoption of agricultural input like fertilizer and pesticide within urban vegetable grower farmers. As the same time, it dealt with the financial gain difference between the adopter and non-adopter groups. Beyond these objectives, the intensity and volume of use of chemical fertilizers and pesticides, respectively, were assessed as a third objective. More to the point of this, factors that affect the joint adoption (both fertilizer and pesticide) at the same time within the households were investigated. Therefore, I believe these circumstances can make the study unique in its context and as it's for the first time in its nature and contents. In reference to the rural agricultural system, urban agriculture has complex different culture. By this means, identifying the determinant of adoption of agricultural inputs may not be easy task as comparing to the rural counterpart area. This point can make this study also unique ever.

CHAPTER FIVE

CONCLUSION AND POLICY IMPLICATIONS

5.1. Conclusion

Here in this study, two agricultural chemical technologies, that is, chemical fertilizer and pesticide have been seen in factors that influence for their adoption decision and their intensity use. Moreover, if adoption of the technologies (fertilizers and pesticides) leads to higher income of the vegetable growers has assessed taking one year income from sales of vegetable as a third focus point.

Besides to the determinant factors which determine the probability of fertilizer and pesticide adoption decision, this study has investigated the affecting factors for intensity of fertilizer and volume of use of the fertilizer and pesticide technologies in Mekelle city in the case of vegetable growers. Heckman two-stage selection model and linear regression(OLS) with a sample of 204 household has been employed in the analysis.

Today, there is a general consensus that fertilizer and pesticide are considered as one of the most important inputs for the achievement of increased agricultural output and productivity in Ethiopia.

Econometric analysis has shown that the likelihood of fertilizer adoption were mostly explained by the education level of household head, farming experience of the household head, cost of fertilizer, perception of the household head to chemical fertilizer, closeness of farm land to homesteads, access to credit, farm size, off-farm activities, and purpose of vegetable producing. On the other hand, the intensity of use of fertilizer were largely explained by the household head age square, household sex, household size, farming experience on vegetable growing, soil fertility, farm land nearness from market center, closeness of farm land to homesteads, farm land size, and household income. The survey result indicated that the intensity of fertilizer in the city in one crop season is about 93.38 kg/ha. On the other hand, one important question might be occurring how enough is the intensity of the applied fertilizer by the growers. This is still very low compared to many other countries like 560 kg in Netherlands, 407 kg in Japan, 314 kg in South Korea, 216 kg in china, and 101 kg in Pakistan.

In the case of financial gain, household size, farmer's farming experience on vegetable cultivation, farmers' perception on chemical fertilizer, off-farm activities, and household income were found as the determinant factors to have an effect on income difference from the sale of vegetable in reference to chemical fertilizer.

The likelihood of pesticide adoption decision were also found affected by age of household head, education level of household head, household sex, farming experience of the household head, closeness of farm land to homestead, access to extension service, used farm size, scarcity of irrigation water, cost of pesticide, and attitude towards the pesticide. In addition, the determinant of pesticide volume of use were age of household head, household age square, sex of household head, household size, purpose of farming. Along with the financial gain impact in respect to pesticide adoption was also determined by farmer's farming experience on vegetable cultivation, household income, and cost of pesticide.

Another important point, both technologies adopters (joint adopter) was identified during the investigation. Therefore, factors that affect the joint adoption were education level of the household head, household size, and perception of the household head to chemical fertilizer, soil fertility, and nearness of market center to the farm land, farm size, household income, and cost of pesticide. And for the income difference in respect of joint adopters, farmer's farming experience on vegetable cultivation, farmers' perception on chemical fertilizer, household income, and cost of pesticide were the determinants.

In regard to the difference sales from vegetable, the result of this paper showed that adopters' income exceed of the non-adopters by far. The result of the study has clearly shown that the both technologies adopters and pesticide adopters were better than the fertilizer adopter was.

5.2. Policy Implications

The possible recommendations of the researcher are that even though efforts by the government has resulted in accelerating the proportion of households that made use of chemical fertilizer and disease control chemicals, still a lot of efforts are expected and needed from the government body. The factors that determine the use of fertilizer and pesticide should address for the better use of them. According to the results of the study, the low production and productivity within the growers seems mainly due to lack of fertility, lack of appropriate treatment of the organic vectors and low intensity of use. Therefore, the concerned government body should double its effort to improve the low production and productivity within the vegetable growers by addressing the critical problems that affect the technologies adoption separately and jointly, and intensity/volume of use of the chemical technologies in the urban vegetable growers of the city.

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7. Appendix

Appendix-1: binary probit result for the determinants Fertilizer adoption

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fertadop	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
hhage	.005023	.0132738	0.38	0.705	-.0209933	.0310392
educ	.8126923	.3793259	2.14	0.032	.0692272	1.556157
gender	-.1703394	.4468673	-0.38	0.703	-1.046183	.7055044
hhsize	-.0349943	.0965261	-0.36	0.717	-.224182	.1541933
fmexp	.0969381	.0350746	2.76	0.006	.0281932	.165683
costfert	-.7055402	.3429963	-2.06	0.040	-1.377801	-.0332798
percfert	1.001893	.3580559	2.80	0.005	.3001162	1.70367
manur	.3317046	.3962411	0.84	0.403	-.4449138	1.108323
fertility	.0925977	.2988022	0.31	0.757	-.493044	.6782393
disfarm	-.1331406	.1063744	-1.25	0.211	-.3416306	.0753495
dismkt	.0036364	.0647257	0.06	0.955	-.1232237	.1304964
extsuppo	.3916628	.4454457	0.88	0.379	-.4813948	1.26472
credit4	-.7565776	.3177963	-2.38	0.017	-1.379447	-.1337082
farmsize	2.599158	.572753	4.54	0.000	1.476583	3.721733
offfarm	-.2186429	.2819436	-0.78	0.438	-.7712423	.3339565
scarwat	-.9043994	.2956465	-3.06	0.002	-1.483856	-.3249429
avgincome	-3.74e-06	.0000158	-0.24	0.813	-.0000348	.0000273
gofarm2	.849588	.5126979	1.66	0.098	-.1552814	1.854457
owplot	-.3839329	.3136114	-1.22	0.221	-.9986	.2307342
owshiptrans	.2465969	.2983838	0.83	0.409	-.3382246	.8314185
_cons	-3.497735	1.21839	-2.87	0.004	-5.885735	-1.109736

Appendix-2: estimation result of heckman output equation of fertilizer

incomevegsal	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhage	-20.02351	79.7451	-0.25	0.802	-177.3558	137.3088
educ	-84.26862	172.1018	-0.49	0.625	-423.8153	255.278
gender	5028.885	3436.858	1.46	0.145	-1751.831	11809.6
hhsize	869.023	510.3948	1.70	0.090	-137.9556	1876.002
fmexp	555.248	261.0576	2.13	0.035	40.197	1070.299
costfert	1883.587	2048.319	0.92	0.359	-2157.626	5924.799
percfert	4767.085	2062.567	2.31	0.022	697.7625	8836.407
manur	-6694.332	4614.388	-1.45	0.149	-15798.25	2409.582
fertility	-691.4048	1492.663	-0.46	0.644	-3636.341	2253.531
disfarm	755.5092	877.6948	0.86	0.390	-976.1305	2487.149
dismkt	186.1676	287.7118	0.65	0.518	-381.4707	753.8059
extsuppo	3147.715	2488.09	1.27	0.207	-1761.139	8056.569
credit	1064.585	1694.9	0.63	0.531	-2279.353	4408.522
farmsize	-697.6207	3595.854	-0.19	0.846	-7792.027	6396.786
scarwat	-2472.138	1626.083	-1.52	0.130	-5680.303	736.0277
offfarm	-3115.923	1683.986	-1.85	0.066	-6438.328	206.4816
gofarm	740.9825	2734.1	0.27	0.787	-4653.235	6135.2
hhincome	.1098185	.0423311	2.59	0.010	.0263017	.1933353
invmill	741.7037	439.5186	1.69	0.093	-125.4405	1608.848
_cons	7520.186	8198.182	0.92	0.360	-8654.339	23694.71

Appendix-3: binary probit result for the determinants Pesticide adoption

pestadop	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]

hhage	-.0412286	.014193	-2.90	0.004	-.0690463	-.0134108
educ	-.268657	.307453	-0.87	0.382	-.8712538	.3339399
gender	1.097857	.5317249	2.06	0.039	.0556954	2.140019
hhsize	-.1126233	.0899683	-1.25	0.211	-.288958	.0637114
fmexp	-.0642583	.0395058	-1.63	0.104	-.1416883	.0131716
costpest	-.8663481	.2655607	-3.26	0.001	-1.386837	-.3458587
attipest	1.156358	.4602323	2.51	0.012	.254319	2.058396
manur	-.3020211	.3603791	-0.84	0.402	-1.008351	.404309
fertility	.2952853	.2746195	1.08	0.282	-.2429591	.8335297
disfarm	.4827076	.1443189	3.34	0.001	.1998477	.7655674
dismkt	-.0331718	.0588418	-0.56	0.573	-.1484996	.0821561
extsuppo	1.410278	.5631094	2.50	0.012	.3066034	2.513952
credit4	.1024172	.2867071	0.36	0.721	-.4595183	.6643527
farmsize	-1.919194	.6514073	-2.95	0.003	-3.195929	-.6424596
offfarm	.2409296	.2989339	0.81	0.420	-.3449702	.8268293
scarwat	.6157434	.2772477	2.22	0.026	.0723479	1.159139
avgincome	-.0000115	.0000172	-0.67	0.504	-.0000453	.0000222
gofarm2	.2802138	.3792745	0.74	0.460	-.4631506	1.023578
owplot	.1198161	.2936964	0.41	0.683	-.4558182	.6954504
owshiptrans	-.7440643	.3034895	-2.45	0.014	-1.338893	-.1492357
_cons	-.9297544	1.340492	-0.69	0.488	-3.557071	1.697562

Appendix-4: estimation result of heckman output equation(pesticide)

incomevegsal	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhage	2.054555	81.53017	0.03	0.980	-158.7996	162.9087
educ	-143.6757	173.2289	-0.83	0.408	-485.4461	198.0947
gender	3446.044	3298.276	1.04	0.297	-3061.257	9953.346
hhsize	783.3275	517.961	1.51	0.132	-238.5788	1805.234
fmexp	621.4788	278.5194	2.23	0.027	71.97664	1170.981
costpest	-3527.749	1731.775	-2.04	0.043	-6944.438	-111.0593
attipest	1512.706	2511.73	0.60	0.548	-3442.788	6468.201
manur	-4119.127	4172.755	-0.99	0.325	-12351.73	4113.472
fertility	-320.4583	1519.543	-0.21	0.833	-3318.427	2677.51
disfarm	480.7256	878.0658	0.55	0.585	-1251.646	2213.097
dismkt	227.577	313.9208	0.72	0.469	-391.7701	846.924
extsuppo	2768.771	2339.799	1.18	0.238	-1847.513	7385.056
credit	132.6894	1759.896	0.08	0.940	-3339.48	3604.859
farmsize	2530.268	3088.63	0.82	0.414	-3563.415	8623.951
scarwat	-2347.189	1581.145	-1.48	0.139	-5466.694	772.3159
offfarm	-2245.975	1672.839	-1.34	0.181	-5546.388	1054.438
gofarm	807.895	2670.833	0.30	0.763	-4461.5	6077.29
hhincome	.1128687	.0444221	2.54	0.012	.0252265	.2005109
invmill1	75.87458	67.87778	1.12	0.265	-58.04424	209.7934
_cons	10071.55	7847.096	1.28	0.201	-5410.306	25553.4

Appendix-5:binary probit result for the determinants both (joint) adoption

adoboth	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
hhage	.0164303	.0139293	1.18	0.238	-.0108707	.0437313

educ	-.5307199	.3011018	-1.76	0.078	-1.120869	.0594288
gender	.8161325	.5329414	1.53	0.126	-.2284134	1.860678
hhsize	.1791812	.0951936	1.88	0.060	-.0073948	.3657573
fmexp	.0174779	.0353351	0.49	0.621	-.0517777	.0867335
costfert	-.0217527	.3309334	-0.07	0.948	-.6703703	.6268648
percfert	1.511563	.3606348	4.19	0.000	.8047319	2.218395
manur	-.6551336	.3565464	-1.84	0.066	-1.353952	.0436844
fertility	-.692724	.3017487	-2.30	0.022	-1.284141	-.1013073
disfarm	.0607113	.1170526	0.52	0.604	-.1687075	.2901301
dismkt	.0668683	.0548736	1.22	0.223	-.0406819	.1744186
extsuppo	.1011407	.4582344	0.22	0.825	-.7969822	.9992636
credit4	.3241655	.27843	1.16	0.244	-.2215473	.8698783
farmsize	-.5174494	.526164	-0.98	0.325	-1.548712	.5138131
offfarm	.0554645	.2880622	0.19	0.847	-.509127	.6200561
scarwat	-.2056884	.2848382	-0.72	0.470	-.7639611	.3525843
avgincome	3.58e-06	.0000121	0.30	0.767	-.0000201	.0000273
gofarm2	-.3670556	.4212055	-0.87	0.384	-1.192603	.4584921
owplot	.1117695	.329632	0.34	0.735	-.5342974	.7578363
owshiptrans	.1689377	.292825	0.58	0.564	-.4049887	.742864
costpest	-.9576398	.27694	-3.46	0.001	-1.500432	-.4148474
attipest	.4101959	.4614516	0.89	0.374	-.4942327	1.314624
_cons	-3.115085	1.330898	-2.34	0.019	-5.723597	-.5065741

Adppendix-6: estimation result of heckman output equation(for both technology adopters)

incomevegsal	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhage	-30.32666	78.85298	-0.38	0.701	-185.9102	125.2569
educ	-102.3402	175.4867	-0.58	0.560	-448.5902	243.9099
gender	4714.889	3451.074	1.37	0.174	-2094.37	11524.15
hhsize	814.5161	495.5333	1.64	0.102	-163.2128	1792.245
fmexp	596.4038	266.9236	2.23	0.027	69.74115	1123.066
costpest	-3585.793	1706.406	-2.10	0.037	-6952.675	-218.9116
attipest	682.1185	2516.044	0.27	0.787	-4282.248	5646.485
costfert	1559.956	2075.67	0.75	0.453	-2535.515	5655.427
percfert	4663.221	2077.241	2.24	0.026	564.6498	8761.792
manur	-5990.568	4395.004	-1.36	0.175	-14662.28	2681.144
fertility	-189.7661	1477.803	-0.13	0.898	-3105.596	2726.064
disfarm	573.4667	855.2666	0.67	0.503	-1114.046	2260.98
dismkt	259.9256	295.2852	0.88	0.380	-322.6969	842.5481
extsuppo	2643.061	2415.366	1.09	0.275	-2122.659	7408.781
credit	192.1872	1746.807	0.11	0.913	-3254.409	3638.784
farmsize	101.523	3517.751	0.03	0.977	-6839.296	7042.342
scarwat	-2440.802	1611.8	-1.51	0.132	-5621.02	739.4152
offfarm	-2516.265	1676.774	-1.50	0.135	-5824.681	792.151
gofarm	542.714	2649.085	0.20	0.838	-4684.153	5769.581
hhincome	.1046968	.0435801	2.40	0.017	.0187095	.190684
invmill2	-.4712148	88.23351	-0.01	0.996	-174.5633	173.6209
_cons	10056.43	7761.197	1.30	0.197	-5257.06	25369.93

Appendix-7: variance inflation factor (VIF) for the continuous explanatory variables

Variable	VIF	Tolerance
Size of farm land	1.48	0.675216

Farm experience	1.44	0.692748
Nearness of farm land to homesteads	1.44	0.696713
Nearness of farm land to market	1.25	0.797692
Household/Family size	1.09	0.914712
Education level of household head	1.03	0.967468
Age of household head	1.07	0.936597
Income of household	1.24	0.805523
Mean VIF	1.36	

Source: computed from own survey, 2014.

Appendix-8: ***Constituency coefficient for dummy variables***

	gender	costpest	attipest	costfert	percfert	manur	fertil~y
gender	1.0000						
costpest	-0.0773	1.0000					
attipest	0.0342	-0.1376	1.0000				
costfert	-0.1063	-0.0459	-0.0234	1.0000			
percfert	-0.0929	0.0072	0.1700	-0.1216	1.0000		
manur	0.1542	0.0648	0.0236	-0.0431	0.1458	1.0000	
fertility	-0.1116	0.0245	-0.0546	0.1164	0.0072	-0.1241	1.0000
extsuppo	0.0843	-0.1173	0.0049	-0.0047	0.0533	0.0580	0.0093
credit	-0.0637	-0.1251	0.1127	0.0078	0.0892	0.0333	0.0598
scarwat	-0.0414	0.0938	0.0923	0.1212	0.0096	-0.0054	-0.0097
offfarm	-0.0742	0.1373	-0.0190	0.0824	0.0659	-0.0272	0.0084
gofarm	-0.0181	-0.0540	0.0049	-0.0047	0.0220	0.0580	-0.0540
hhincome	-0.0256	-0.0370	0.1252	-0.0479	0.3348	-0.0152	0.0525

	extsuppo	credit	scarwat	offfarm	gofarm	hhincome
extsuppo	1.0000					
credit	0.0122	1.0000				
scarwat	-0.1818	0.0053	1.0000			
offfarm	-0.0245	0.1280	-0.0037	1.0000		
gofarm	-0.0389	0.0122	-0.0891	0.0075	1.0000	
hhincome	0.0286	0.1463	0.0914	0.1002	-0.1778	1.0000

Appendix-9: Linear Regression for Fertilizer intensity of use

usefert	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhage	.0032111	.0059958	0.54	0.596	-.0089874	.0154097

```
     hhagesq |  -.0000987    .000056    -1.76   0.087    -.0002127    .0000152
        educ |  -.0893218   .1139401    -0.78   0.439    -.3211347    .1424911
      gender |   .3528818   .1621774     2.18   0.037     .0229293    .6828342
      hhsize |  -.1560767   .0448606    -3.48   0.001    -.2473462   -.0648072
       fmexp |   .0270107   .0087255     3.10   0.004     .0092585    .0447628
    costfert |  -.0897937   .0728809    -1.23   0.227     -.238071    .0584836
    percfert |   .1868096   .1636408     1.14   0.262      -.14612    .5197393
       manur |  -.1101246   .1081531    -1.02   0.316    -.3301638    .1099147
   fertility |   .2292513   .0908214     2.52   0.017     .0444739    .4140288
     disfarm |  -.1512975   .0422269    -3.58   0.001    -.2372088   -.0653862
      dismkt |   .2222299   .0248734     8.93   0.000     .1716246    .2728352
    extsuppo |   .1933972   .1336616     1.45   0.157    -.0785395    .4653339
     credit4 |   .1837982   .1218887     1.51   0.141    -.0641863    .4317827
    farmsize |   2.441446   .1644236    14.85   0.000     2.106924    2.775968
     offfarm |   .0313677   .0765351     0.41   0.685    -.1243443    .1870796
     scarwat |   .0094577   .0704943     0.13   0.894    -.1339641    .1528795
    hhincome |  -4.74e-06   1.65e-06    -2.87   0.007    -8.09e-06   -1.38e-06
     gofarm2 |  -.1239245   .1431065    -0.87   0.393    -.4150767    .1672278
       _cons |   .1696512   .4396595     0.39   0.702    -.7248428    1.064145
------------------------------------------------------------------------------
```

Appendix-10: heterokedacity- test for intensity of use of fertilizer

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Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of usefert

         chi2(1)      =     0.21
         Prob > chi2  =   0.6478
```

Appendix-11: Linear Regression for pesticide volume of use

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------------------------------------------------------------------------------
             |               Robust
     usepest |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
```

hhage	-.0246901	.0124562	-1.98	0.056	-.0500948	.0007145
educ	.0880579	.0371107	2.37	0.024	.0123701	.1637457
gender	-1.595468	.4373188	-3.65	0.001	-2.487386	-.7035509
hhsize	-.2559933	.1311205	-1.95	0.060	-.5234153	.0114288
fmexp	-.0671333	.0475462	-1.41	0.168	-.1641044	.0298378
costpest	-.0884934	.3085934	-0.29	0.776	-.7178738	.540887
attipest	-.1394612	.7072445	-0.20	0.845	-1.581896	1.302973
manur	-.3048931	.3709405	-0.82	0.417	-1.061431	.4516451
fertility	.2224953	.2623198	0.85	0.403	-.3125093	.7575
disfarm	.1867572	.1530318	1.22	0.232	-.1253533	.4988676
dismkt	.0228476	.1095579	0.21	0.836	-.2005971	.2462923
credit	-.1357753	.3235211	-0.42	0.678	-.7956009	.5240503
farmsize	-.2397743	.8479341	-0.28	0.779	-1.969147	1.489599
offfarm	.557058	.3308394	1.68	0.102	-.1176935	1.231809
scarwat	-.1430197	.24637	-0.58	0.566	-.6454947	.3594552
hhincome	-2.37e-06	6.92e-06	-0.34	0.734	-.0000165	.0000117
gofarm	.380756	.2924535	1.30	0.203	-.2157068	.9772188
_cons	5.351393	1.614828	3.31	0.002	2.057929	8.644857

Appendix-12: heterokedacity- test for volume of use of pesticide

```
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of usepest
         chi2(1)      =     1.66
          Prob > chi2  =   0.1979
```

APPENDIX-15: QUESTIONNAIRE

DEPARTMENT ECONOMICS, FACULTY OF BUSINESS AND ECONOMICS, MEKELLE UNIVERSITY.

MSc. RESEARCH QUESTIONNAIRE

I. INTRODUCTION:

Dear respondents, this questionnaire is designed to ask for your responses on adoption of modern agricultural technologies. In interviews with you, I'll be asking you the questions that are listed below and we will fill out this form together. The result of this questionnaire will be used for academic purposes only. Therefore, you are kindly requested to provide genuine response, in independent manner.

II. GENERAL INSTRUCTIONS TO ENUMERATORS:

i. Make brief introduction to the respondent before starting the interview (greet them, tell your name, get her/his name, and make clear the purpose and objective of the study that you are undertaking).

ii. Please ask the question clearly and patiently until the respondent understands.

iii. During the process put the answers of each respondent both on the space provided and encircle the choice or tick mark as required

III. IDENTIFICATION PARTICULARS:

Respondent's name:____________________________

Date of Interview: __________________

Sub-city: _______________________

Kebele: ____________________

Location/Site: ________________

A. HOUSEHOLD DEMOGRAPHIC INFORMATION:

1. Age of the household/firm head. ______________________

2. Marital status of the household/firm head:

Status	*Tick the appropriate*	*Status*	*Tick the appropriate*
Single (1)		Widowed (4)	
Married (2)		Separated (5)	
Divorced (3)			

3. Gender of household/firm head:

☐ Male (1) ☐ Female (0)

4. Educational level of the household/firm head(respondent): -________________

Years of schooling: 0=Illiterate 1=Religious school 2= 1stgradecomplete 3=2ndgrade complete 4=3rdgrade complete 5=4thgrade complete 6=5thgrade complete etc

5. Household/firm size (specify in number) _________members? From the total what numbers are: ☐ Male(1)_______ ☐ Female(0)_______

6. Is farming your only occupation?

☐ Yes [1] ☐ No [0]

7. If no, which other activities do you engaged in?

s/n	*Engaged activities*	*Tick the appropriate once*
1	Employment in public sector [1]	
2	Employment in private sector [2]	
3	Employment in NGOs [3]	
4	Trading/Commerce [4]	
5	Artisan/Carpentry [5]	
6	Daily laborer [6]	
7	Masonry [7]	
8	Pottery [8]	
9	Weaving [9]	
10	Tailor [10]	
11	Grinding meal [11]	
12	Broker [12]	
13	Other (Mention) [13] .___________________________	

8. How many household members work off-farm?__________
Male(1)_______ Female(0)_______

9. How much did you earn in the last crop seasons in general?______________

Source of income	*Unit*	*Quantity*	*Price per unit (**Birr**)*	*Total income (**Birr**)*
1. Cereal production				
Teff				
Barley				
Wheat				
Maize				
Oilseeds				
Others (specify)				
2. Livestock sales (indigenous cattle)				
Cattle				

Cattle products (milk, butter, etc.)				
Sheep, goat, donkey, mule, camel etc trading				
Poultry				
poultry products (egg)				
3. Livestock sales (cross breed cattle)				
Cattle				
Cattle products (milk, butter, etc)				
Sheep, goat, etc.				
Poultry				
Poultry products (eggs)				
4. Off-farm activity				
Wage employment in private sector				
Wage employment in public sector				
Daily labor				
Weaving				
Pottery				
Masonry				
Shop keeping				
Grinding meal				
Tailor				
Rent of oxen, donkey,				
Rent of house				
Sale of fuel-wood				
Sales of charcoal				
Remittance				
Sales of animal dung				
Other petty trade				
Other sources (Mention)				

B. GENERAL INFORMATION:

10. For how long have you been practicing vegetable cultivation? (yrs) ______.
11. What type of vegetable do you grow in general? Tick all that apply and state the size of land use for each?

s/n	*Vegetable*	*Yes(1)*	*No(0)*	*Land(in hectares)*
1.	Onion [1]			
2.	Potato [2]			
3.	Green Pepper[3]			
4.	Hot Pepper[4]			
5.	Carrot [5]			
6.	Tomato[6]			
7.	Cabbage[7]			
8.	Garlic[8]			
9.	Sweet Potatoes [9]			
10.	Beet root [10]			

11.	Lettuce [11]			
12.	Salad [12]			
13.	Cauliflower [13]			
14.	other(Mention) [14] .________________			

12. Which vegetable crops do cultivate/grow/ often?

s/n	Vegetable	Yes(tick)	s/n	Vegetable	Yes(tick)
1	Onion [1]		8	Garlic[8]	
2	Potato [2]		9	Sweet Potatoes [9]	
3	Green Pepper[3]		10	Beet root [10]	
4	Hot Pepper[4]		11	Lettuce [11]	
5	Carrot [5]		12	Salad [12]	
6	Tomato[6]		13	Cauliflower [13]	
7	Cabbage[7]		14	other(Mention) [14] .________________	

13. How many household/firm members work on the farm?

Worker	Female[0]	Male[1]	Total
Full time[1]			
Part time[2]			
Paid family member[3]			
Unpaid family member[4]			

14. Do you ever hire labors to work on your farm?

☐ Yes (1) ☐ No (2) ☐ sometimes (3)

15.1. If yes, in which activity? **Tick** the appropriate one from this table.

Farm Operation	No. of people	duration of labor contract	Wage Rate/day	Total Cost
Land clearing[1]				
Bed Preparation[2]				
Nursery work[3]				
Planting[4]				
Weeding/tsahyay[5]				
Fert. Application[6]				
Watering[7]				
Harvesting[8]				
Other(mention)[9]				

15. Do you belong to any vegetable growing association/group?

☐ Yes (1) ☐ No (0)

16.1. If yes, how many times do you attend meetings in a period of one year with the association? __________ times.

16.2. What benefits do you derive from the association/group? (mention)

1. ____
2. ____

C. USE OF PESTICIDES:

17. Have you used pesticides on your vegetable field during the last year?

☐ Yes [1] ☐ No [0]

17.1. If yes, please fill out the table below of you used the chemicals:

Vegetable types	***Pesticides***		
	Quantity of chemical used(kg/liters)	***Unit purchasing cost (birr/kg or liter)***	***Total cost (birr)***
Onion [1]			
Potato [2]			
Green Pepper[3]			
Hot Pepper[4]			
Carrot [5]			
Tomato[6]			
Cabbage[7]			
Garlic[8]			
Sweet Potatoes [9]			
Beet root [10]			
Lettuce [11]			
Salad [12]			
Cauliflower [13]			
other(Mention) [14] .________________			
Vegetable types	***Herbicides***		
	Quantity of chemical used(kg/liters)	***Unit purchasing cost (birr/kg or liter)***	***Total cost (birr)***
Onion [1]			
Potato [2]			
Green Pepper[3]			
Hot Pepper[4]			
Carrot [5]			
Tomato[6]			
Cabbage[7]			
Garlic[8]			
Sweet Potatoes [9]			
Beet root [10]			
Lettuce [11]			
Salad [12]			
Cauliflower [13]			
other(Mention) [14] .________________			

Vegetable types	***Fungicides***		
	Quantity of chemical used(kg/liters)	***Unit purchasing cost(birr/kg or liter)***	***Total cost (birr)***
Onion [1]			
Potato [2]			
Green Pepper[3]			
Hot Pepper[4]			
Carrot [5]			
Tomato[6]			
Cabbage[7]			
Garlic[8]			
Sweet Potatoes [9]			
Beet root [10]			
Lettuce [11]			
Salad [12]			
Cauliflower [13]			
other(Mention) [14] .___________________ .___________________			
Vegetable types	***Insecticides***		
	Quantity of chemical used(kg/liters)	***Unit purchasing cost(birr/kg or liter)***	***Total cost (birr)***
Onion [1]			
Potato [2]			
Green Pepper[3]			
Hot Pepper[4]			
Carrot [5]			
Tomato[6]			
Cabbage[7]			
Garlic[8]			
Sweet Potatoes [9]			
Beet root [10]			
Lettuce [11]			
Salad [12]			
Cauliflower [13]			
other(Mention) [14] .___________________			

18. Where do you get the **pesticides** you are using for vegetable growing?

Supplier of the pesticides	*Tick the appropriate one*
Government [1]	
Non-governmental organization [2]	
Unions [3]	
Private individuals [4]	
Other(Mention) [5] . ___________________________________	

19. What is your Attitude about using pesticides?

☐ good (1) ☐ not good (2) ☐ I don't know (3)

D. USE OF FERTILIZER:

20. Have you used chemical **fertilizers** on the vegetables during the last year?

☐ Yes [1] ☐ No [0]

20.1. If yes, please fill out this table

Types of fertilizers	*Quantity of fert. Used (kg)*	*Unit purchasing cost (birr/kg)*	*Total cost (birr)*
Urea			
Dap			

21. Where do you get the **fertilizer** you are using for vegetable growing?

Supplier of the fertilizer	*Tick the appropriate*
Government [1]	
Non-governmental organization [2]	
Unions [3]	
Private individuals [4]	
Other(Mention) [5] . ______________________________	

22. Have you used **manure** on the vegetables during the **last year**?

☐ Yes [1] ☐ No [0]

22.1. If yes, where did you get it (the manure)?

☐ own [1] ☐ purchased [0]

22.2. If purchased, fill out the following table.

Quantity of manure used (kg)	*Purchasing cost (birr/kg)*	*Total cost (birr)*

23. Which do you prefer to use?

☐ Chemical fertilizer [1] ☐ manure/compost [2] ☐ both [3] ☐ neither [4]

And why____

24. What is your Attitude about using chemical fertilizer?

☐ good (1) ☐ not good (2) ☐ I don't know (3)

E. ACCESS TO CREDIT:

25. Do you ever borrow money to finance vegetable cultivation in the last year?

☐ Yes (1) ☐ No (0)

25.1. If yes, please fill out this table:

Source of loan	*Amount borrowed*	*duration*
Friends/relatives[1]		
Local money lenders [2]		
Banks [3]		
MFI(micro finance) [4]		
Cooperative lenders[5]		
NGOs[6]		
Others(Mention) [7] .________________		

25.2. What do you used for, the money you borrowed?

Use of the money	*Tick the appropriate once*
Buying fertilizer [1]	
buying chemicals(pesticides, etc) [2]	
payment for hired labor [3]	
covering food expenses [4]	
health/school fees [5]	
Payment for rent of land [6]	
Purchasing improved seeds of vegetables [7]	
Purchasing agri. Instruments [8]	
others(Mention) [9] .________________________ .________________________	

25.3. If not borrowed, why? (Tick).

s/n	*Reasons*	*Tick the appropriate once*
1	Not available [1]	
2	High Interest Rate [2]	
3	I don't want to borrow [3]	
4	Investment risk [4]	
5	Lack of collateral [5]	
6	Other reason(mention) [6] .____________________ .____________________	

F. LAND USE:

26. What is the total size of your vegetable farm? (ha)___________.
27. How do you acquire the land you are using for vegetable cultivation?

    ☐ own [1] ☐ rented [2] ☐ *Contract Leased* [3] ☐ share cropping [4]

    ☐ other[5] (specify)__________________________

    27.1. If rented, what is the cost? ______________birr per season.
28. How do you explain the **fertility** of the land you are using for vegetables cultivation? ☐ fertile [1] ☐ not fertile[2] ☐ average(3)
29. What is the farm distance from your home? ______ km/_____ minutes way/.

G. WATER USE:

30. What source of water do you use for growing vegetables/or irrigation/?

Sources	*Tick the appropriate*	*Sources*	*Tick the appropriate*
Stream [1]		tap water [5]	
Lake [2]		dugout [6]	
well [3]		Others [7]	
Small pond [4]			

31. How often do you water the vegetables?

Frequency	*Tick the appropriate*	*Frequency*	*Tick the appropriate*
Once a day [1]		Once every three days[4]	
Twice a day[2]		Other [5] mention .___________________	
Once every two days[3]			

32. Do you have any access problem of water to use for your vegetable?

    ☐ Yes [1] ☐ No [0]

    32.1. If yes, what is it?____

    ____

33. Do you pay for the water you use for irrigation? ☐ Yes [1] ☐ No [0]

    33.1. If yes, how much per month?________________________________

H. OUTPUT AND MARKETING:

34. For what purpose do you grow vegetables?

    ☐ for own-consumption [1] ☐ for markets [2] ☐ for both [3]

    ☐ others [4] mention___________________

35. Please indicate the quantities of vegetables harvested in the **last year** from your field.

s/n	*Vegetable types*	*Amt in quintal*	*Selling price*	*Total sales*
1	Onion			
2	Potato			
3	Green Pepper			
4	Hot Pepper			
5	Tomato			
6	Carrot			
7	Cabbage			
8	Garlic			
9	Sweet Potatoes			
10	Beet root			
11	Lettuce			
12	Salad			
13	Cauliflower			
14	Other(mention) .______________ .______________			

36. Where do you sell your vegetable produces?

☐ on farm [1] ☐ at market [2] ☐ at home [3] ☐ at hotels [4]

☐at restaurants [5] ☐ through service cooperatives [6]

☐other [7] (mention)___________________________

37. What is the market distance from your farm land?_____km/____minutes way/.

38. What do you use for transporting of your vegetable produce?

☐ pack animal [1] ☐ Cart [2] ☐ Car/truck [3] ☐ human labor [4]

☐bajaj [5] ☐ bycle[6] ☐ Other [7] (specify) ______________

39. Where do get the thing that you use for transportation?

☐ own [1] ☐ rented [2]

40. Has there been a change in outputs since you began using/adopting/ the technologies, which are mentioned above?

☐ Yes[1] ☐ No[2] ☐ sometimes [3]

41. How many quintals of vegetable did you get after using the pesticides *per hectare in one harvesting season*?________________.

41.1. What is the difference of amounts of the produces from before adopting the pesticide technology? __________________ sack/quintals/.

42. How many quintals of vegetable did you get after using of the **fertilizers** *per hectare in one harvesting season*? _________________________________.

42.1. What is the difference of amounts of the produces from before adopting fertilizers? ________________________sack/quintals/

43. On the average, how much do you earn from the produce per season? ______________birr.

44. What major problems do you face in marketing your produces/vegetables?

☐ Lack of market options [1]
☐ Lack of storage [2]
☐ Means of transport [3]
☐ Price fluctuation [4]
☐ Consumer demand [5]
☐ Marketing information [6]
☐ others [7] (specify)________________________________

I. AGRICULTURAL EXTENSION SERVICE:

45. Have you ever given any training on the chemical (technology) applications?

☐ Yes (1) ☐ No (0)

46. If yes, on which application did you get trainings?

☐ on chemical fertilizer [1] ☐ on manure [2] ☐ on pesticides [3]
☐ other(mention)[4]_______________________________________

47. Are you satisfied with the training? ☐ Yes (1) ☐ No (0)

48. Do you have contact(s)/visit with any extension agents as regards of the chemicals uses/applications/? ☐ Yes [1] ☐ No [0]

48.1. If yes, how often do you have contacts/visits on **pesticides** use?

Contacts with extension agents	*Tick the appropriate*
Once a week (1)	
Once a month (2)	
Once in three months (3)	
Once in more than three months (4)	
other(mention)(5) . _________________________	

48.2. If yes, how often do you have contacts/visits on **fertilizer** uses?

Contacts with extension agents on fertilizer use	*Tick the appropriate*
Once a week (1)	
Once a month (2)	
Once in three months (3)	
Once in more than three months(4)	
other(mention)(5) . _________________________	

48.3. Are you satisfied with the visits of the Extension agents?

☐ Yes [1] ☐ No [0]

J. CONSTRAINTS/CHALLENGES:

49. Which of the following problems do you face/encounter/ in adopting the technologies?

Problem encountered	*Tick the appropriate*
High cost of pesticide [1]	
Lack of supply of the pesticides [2]	
High cost of chemical fertilizers [3]	
Lack of supply of the chemical fertilizers [4]	
Lack of credit facilities [5]	
Lack of supply of agricultural inputs (improved vegetable seeds, irrigation inputs, etc) [6]	
Lack of know-how to use the chemical technologies [7]	
Shortage of irrigation water [8]	
Shortage of farm land [9]	
Lack of technical supports [10]	
Lack of labor [11]	
Lack of farming experience on vegetable growing [12]	
others(Mention) [13] .________________________________	

K. SUGGESTIONS:

50. What suggestions will you give:

50.1. About the chemical technologies you adopted?

☐ Very important[1] ☐ not important as expected[2] ☐ I don't know[3]

50.2. About the market of vegetable produces?

☐ Good market/price[1] ☐ not good price[2] ☐ average[3]

50.3. About the technical supports?

☐ enough[1] ☐ not enough[2] ☐ average[3]

50.4. About the agricultural input supply?

☐ enough [1] ☐ not enough [2] ☐ average [3]

Interviewer's name: ________________________
Signature: ______________________

Thank you for your cooperation!