IMPROVING THE COMPOSTING OF MANURE MATERIALS FROM FARMLANDS: A STEP TOWARDS CLIMATE SMART AGRICULTURE IN PAKISTAN

By

Khizar Nazir
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Supervisor

Dr. Shujaat Farooq

MPhil Environmental Economics
PIDE School of Economics
Pakistan Institute of Development Economics, Islamabad

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Pakistan Institute of Development Economics, Islamabad

PIDE School of Economics

CERTIFICATE

This is to certify that this thesis entitled: **"Improving The Composting of Manure Materials from Farmlands: A Step Towards Climate Smart Agriculture in Pakistan"** submitted by **Mr. Khizar Nazir** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Environmental Economics.

Supervisor: Dr. Shujaat Farooq Signature: _____

External Examiner: Dr. Aneel Salman Signature: _____

Head,
PIDE School of Economics: Dr. Shujaat Farooq Signature: _____

AUTHOR'S DECLARATION

I Khizar Nazir hereby state that my M.Phil. thesis titled "Improving the composting of manure materials from farmlands, a step towards climate-smart agriculture in Pakistan" is my work and has not been submitted previously by me for taking any degree from Pakistan Institute of Development Economics or anywhere else in the country/world.

At any time if my statement is found to be incorrect even after my Master' the university has the right to withdraw my M.Phil. degree.

Date: 15 May 2022

Signature of Student

Khizar Nazir

DEDICATION

My Parents, Brothers, and Mentors are those who look up to nothing without the love and support, who have been there for me at every step of my life. They guided me and I discovered a route forward. I am nothing without my mother who has been there for me throughout my schooling. Parents create the kid, but few of them polish the child's abilities, and they are my mentors; without them, I may not be here.

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ABSTRACT

The agriculture sector is the backbone of Pakistan; it delivers a wide range of employment within the country and food security. According to the Pakistan Bureau of Statistics (PBS), arable land is 30.93 (million hectares). The farmers in our country are using 80-90 percent commercial fertilizers to cultivate their crops. The study has cleared path for us to understand how farmers might reduce their production costs by eliminating the use of commercial fertilizers through efficient animal manure management. Furthermore, the study encourages readers to learn how fertilizers imports may be decreased in the country, resulting in significant national savings. We would also like to know the government initiatives and policies related to organic farming through both secondary and primary data. Composting thorough (bio-fermenter) is a clever approach to transform manure into a useful resource, very limited scientific literature in detail is available on techniques for composting in small, medium, and large livestock farms. However, such a reality requires the identification of easy methods to apply to sustainable manure management. For this purpose, in-depth interviews of agricultural department experts and stakeholders, have been conducted for the cost-effectiveness of manure composting. The country has a lot of potential in the form of animal manure; estimated secondary data showed that tons of livestock manure are generated every year, but it isn't used in the country. The primary data has been collected in the form of a structured and semi-structured questionnaire. Farmers' awareness and understanding of new manure composting methods have been examined using the KAP survey method. Manure composting using (bio-fermenter) plant is a successful way to allow the farmers to turn manure into a product with profitable placement for the production of crops. Composting through (bio-fermenter) plants have several advantages, including the ability for farmers to produce their agricultural fertilizer and lower production costs, among other soil benefits. According to the results of cost-benefit analysis of collected data, crops growing under the bio-fermenter plants is tremendous potential for farmers to cut production costs while increasing output. Furthermore, research has revealed that these types of manure management methods should be widely used, particularly in organic agricultural systems.

Keywords: Livestock manure, bio-fermenter plant, Policy review, KAP method, Environmental impact.

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LIST OF ABBREVIATIONS

AMIS	Agricultural Marketing Wing Punjab
BCR	Benefit-Cost Ratio
CSA	Climate-Smart Agriculture
CK	Composting Knowledge
CA	Composting Attitude
CP	Composting Practice
CBA	Cost-Benefit Analysis
FY	Fiscal Year
FAO	Food Agriculture Organization
GHG	Green House Gases
GDP	Gross Domestic Product
IRR	Internal Rate of Return
KAP	Knowledge Attitude Practices
LRRI	Land Resources Research Institute
NARC	National Agriculture Research Institute
NRSP	National Rural Support Programme
NPV	Net Present Value
NFDC	National Fertilizer Development Centre
PARC	Pakistan Institute of Research Council
PBS	Pakistan Bureau Statistics
RT	Net Cash Flow in Single Period
ZTBL	Zarai Tarqati Nank Limited
AIOU	Allama Iqbal Open University
MNSFR	Ministry of National Food Security and Research Islamabad

CHAPTER 1

INTRODUCTION

1.1. Introduction

Agriculture is the backbone of the Pakistan economy, according to Pakistan economic survey 2020-2021, it contributes 19.2 percent to the GDP, providing a living for almost 65-70 percent of rural residents, and employing 38.5 percent of the entire country's labor force. Agriculture growth rate has been constrained by shrinking arable land, water shortages and labor shift from rural to urban areas. To increase the agriculture productivity, therefore, requires adoption of new approaches. Realizing the importance of agriculture, the government is also trying to give farmers maximum relief through agriculture input regime to increase yields of major seasonal crops within the country. The programs designed by the current government for agriculture included "Agriculture Transformation Plan" including additional implements, and subsidy on new conservation approaches.

According to Pakistan economic survey domestic production of fertilizer during fiscal year 2021(March-July) increased by 5.9 over the same period of the previous year. Pakistan meets around 84 percent of its fertilizer requirements through local production while the remaining is met through imports. Even though domestic production of chemical fertilizers is insufficient to meet the country's requirements. Subsequently, healthy growth in prices of fertilizers assumed due to increase in the support price of wheat. As a result, the price of DAP increased by 12.2 percent and likewise. According to recent economic survey of Pakistan 2020-2021, total availability of fertilizer increased by 0.3 percent during the last year.

Many studies has indicated, every year chemical fertilizers are imported to suit the needs of the country (Khatri-Chhetri, Aryal, Sapkota, & Khurana, 2016). Apart from that, several studies have proven that the usage of nitrogen fertilizer is damaging to both fertility and the environment. According to national fertilizer centre (NFC), total availability of urea during Kharif season 2020 was 3,695 thousand tons, and 3,104 thousand tons of domestic production. Availability of DAP was 1,456 thousand tons and 547 thousand tons of imported supplies and 409 thousand tons of local production.

Livestock having a share of 60.07 percent in agriculture and value addition 11.5 percent to the GDP during fiscal year 2021. According to the Pakistan economic survey 2020-2021 almost 35-40 percent rural families are engaged in livestock production and earning from this source. Also, the gross value addition of livestock increased to Rs. 1,505 billion 2020-2021 form RS 1,461 billion 2019-2020 an increase of 3.0 percent. There are millions of livestock in the country. The livestock industry makes for two-thirds of the total GDP contribution. Every year, a tremendous number of natural resources in the form of manure are wasted. Livestock over the years in Pakistan has emerged as the largest sub-sector in agriculture. It is a source of foreign exchange earnings and contributes about 3 percent to total exports. The government has now concentrating on this sector for economic growth, food security, and other alleviation in the country. The regulatory measures are added to improve per unit animal productivity by improving financial protection, management practices, and factory farming (Campbell, Watts, Dwyer, & Franklin, 2012; Duan et al., 2015). Table 1 explains the total livestock population in the country. The mentioned facts and figures related to livestock population and their importance urging himself; by using livestock manure the farmers could get rid of expensive use of fertilizers and their harmful effects. Livestock household farmers have the choice to use their organic fertilizers through manure composting.

Table 1: Livestock Population of Pakistan (Thousand heads 000)

Species	**2017-2018**	**2018-2019**	**2019-2020**
Cattle	46100	47800	49600
Buffalo	38800	40000	41200
Camels	1100	1100	1100
Horses	400	400	400
Mules	200	200	200
Total	**86600**	**89500**	**92500**

Source: Government of Pakistan Finance Division (2020-2021)

The above table 1, clearly illustrates that the livestock population has expanded over the previous three years; animal manure might be a valuable asset to farmers as an organic fertilizer. Moreover, studies (Makate, Makate, & Mango, 2018) have suggested that organic farming is a focus-based concept that involves new technologies. Also helpful for farmers to transition from current strategies to more climate-aware and cost-effective practices.

The present studies suggested that agriculture production systems require new adaptations to ensure the food and livelihood security of farming communities (Mwongera et al., 2017). The agriculture sector's performance in FY2020 was higher than the previous year, and it also surpassed other sectors. Over the last few decades, increasing weather risks and climate change have threatened the agricultural production systems and food security across the world. Although global food production has decreased in recent times, almost 800 million people have insufficient food, especially in South Asian countries. Many previous types of research show, organic farming may alternative method to increase productivity, improve resilience to climate variability, and reduce greenhouse gas emissions (Bell et al., 2018).

Manure composting has historically been promoted as both the basis of organic method gardening, farming and as a waste management technique (Blum, 1992). Once the farmers apply organic fertilizers to farmland it reaches the soil by balancing the nutrition and ensuring their more prominent growth. Composing is the process of preserving manure and using it as organic fertilizers by using suitable methods. Despite the various benefits of organic farming, the adaptation rate is very low according to (Duan, Naidu, Thavamani, Meaklim, & Megharaj, 2015). Many factors can influence the adaptation of organic farming technologies such as socio-economic characteristics of farmers and attributes of technologies.

Also, according to some studies, shifting towards organic farming has improved their economic situation, allowing farmers to escape from poverty and other constraints in rural areas; (Makai & Molinas, 2013). Composting has become a valuable way of producing organic fertilizer while eliminating waste products and possible contaminants. However, as compared to our neighboring nation China, the rate of adoption of manure composting fermented technology is low in Pakistan.

The main objective of the study is to promote composting techniques on-the farms using livestock manure, with awareness and new techniques. For this purpose, a series of on-farm composting experiences are reported to provide satisfactory solutions. The suggested

composting solutions have been chosen with the specific aim of containing costs of production to make the action economically effective for the farmers of Pakistan.

Therefore the adoption of manure management approach and its benefits inextricably linked to an understanding of compost or its benefits, according to facilities within farms (Palese et al., 2020). Our study has also identified and examined the government policy and initiatives regarding organic farming. As a result, one of the goals of this research is to calculate the internal rate of return (IRR) on a manure composting plant investment, which has assisted investors to decide whether or not to engage in this industry.

1.2. The Case of Pakistan

Agriculture is the foundation of the Pakistan economy, with a total land area being 79.61 million hectares. Almost 22.3 million hectares are dedicated to agriculture with 19.12 million hectares irrigated and 3.67 million hectares rain-fed Pakistan Economic Survey (2013-2014). The agricultural sector is growing rapidly in Pakistan however; difficulties such as climate change, insect infestations, water scarcity, and other factors have stopped agriculture output from reaching its full potential. The fertilizer's domestic production increased by 2.6 percent in 2018-19 compared to the same period the previous year; this gain might be attributed to the higher urea fertilizer production. According, to the food and agriculture organization (FAO), global fertilizer outlook (2018), Pakistan's need for nitrogen (N) and phosphorous (P) may rise by 3 and 4 percent accordingly, in the next years.

Fertilizers' usage in countries like Pakistan is growing year after year, while local inorganic fertilizers production capacity is insufficient to fulfill the country's need. Similarly, in the recent statistics cost of urea fertilizers increased by 11 percent, while the cost of DAP, increased by 3 percent. The supply-demand gap of commercial fertilizers within the country is an alarming situation. In addition, several studies have shown, the use of chemical fertilizers harms both soil fertility and the health of the soil.

The farmers in Pakistan, are facing a high cost of production in the form of commercial fertilizers; with low yields. The goal of the study is to capitalize on the livestock sector's potential for economic growth, food security, and rural socioeconomic uplift. The livestock population in Pakistan is about 495.55 MH-million heads (Livestock Census 1996-2005). Based on the number of animals, it may be estimated how much fertilizer intake can be reduced through proper composting of animal manure in the agriculture sector of Pakistan.

It has also made it possible for researchers to have a better understanding of how effective manure management may reduce production costs while improving yield.

1.3. Problem Statement

South Asia is the second-largest fertilizers consumer in the world, accounting for 149 percent of fertilizer consumption and 160 kilograms per hectare in arable land (GÜLER, 2006). Each country of the region imports an enormous quantity of chemical fertilizers annually to meet the demand for crops and increase food production. To prevent the excessive usage of inorganic fertilizers, many countries in the world have introduced a new technique of manure composting. It is now used in agriculture and a very good substitute for human health and to increase farmer productivity by minimizing the cost.

In Pakistan, farmers are using inorganic fertilizers to raise the productivity of crops. The demand for fertilizers has also increased from thousand 3621.5 tons (2012-13) to thousand 4089.5 tons (2013-14), an increase of 1.1 percent per year (Pakistan Bureau of Statistics, 2013-14). Pakistan has major seasonal rabi and Kharif crops like wheat, rice maize, cotton, and sugarcane. Fertilizers intake for the cultivation of these crops together with irrigation of water and high-quality seed plays an essential role in increasing agricultural output but also causing damage in various ways. Due to the high use of commercial fertilizers studies have predicted that the essential nutrients are washed off from the soil and result in low production. The current administration has launched the "Prime Minister Agriculture Emergency Programme" worth 277 billion rupees to modernize the agriculture and livestock industries. The program's goals include increased water availability, soil conservation, and shrimp aquaculture.

The widespread use of fertilizers has not only been expensive, but it has also proven detrimental to soil fertility and human health. The study has considered that Pakistan has abundant livestock, with gross value addition of livestock increased from 1,430 billion rupees in (2018-19) to 1,466 billion rupees in (2019-20). Also representing a 2.5 percent raise over the same time last year. The majority of farmers have their livestock, using manure composting technology farmers, could effectively manage manure and turn it into a resource (fertilizer’s replacement).

1.4. Objectives of the Study

The key objectives of the study are following:

i. To analyze the knowledge, awareness, and behavior of farmers about manure composting and utilization;
ii. To review the government initiatives that how much they are effective in promoting organic farming across provinces;
iii. To describe efficient and cheaper manure composting methods that farmers in Pakistan can easily use, and to determine the cost-benefit analysis of manure composting.

1.5. Research Questions

i. Are the farmers aware about profitable solution of manure composting in field?
ii. Is there any policy direction that the government should pursue through the outcome of the research?
iii. Which farming system is more cost-effective for famers i.e., bio-fermenter plant or traditional?

1.6. The Significance of the Study

There are many researches about the agriculture conservation approaches in Pakistan, but our study aims that farmer could use their livestock manure to produce organic fertilizer effectively. The organic fertilizer is not only cost effective for famers, also need of hour to save health of soil and produce sustainably. Our study will enlighten constraints of farmers of not using manure livestock as fertilizer. We have considered only large livestock for manure management. There are many types of composting but in our study, composting through bio-fermentation has been considered. In which farmer could dig specified ditch and dip manure into it. Manure compositing techniques are also discussed in chapter 5 thoroughly.

Therefore, the present study is going to fill the gap between new techniques and their adoption in agriculture. In addition, the study has encouraged policymakers and stakeholders to construct the required policy for organic agriculture in the country. Furthermore, farmers suffer badly in terms of productivity due to high costs. As a result, the purpose of this research is to determine, how farmers in Pakistan may transform into more resilient and sustainable agriculture. The primary goal of this study is to promote manure composting techniques, with the understanding that successful implementation of such

techniques is necessary. The composting method has a moderate to medium degree of complexity and may be used on a variety of scales (small, medium, and large scale). The study has helped us to understand, what interventions government should make to motivate or facilitate the farmers for the manure composting. The main purpose is to maximize the potential of the livestock industry for numerous advantages for farmers, agricultural production, and rural socioeconomic uplift. Local farmers are searching for cost-effective animal process innovation that would allow them to produce with few agricultural resources.

1.7. Organization of the Study

The study is organized into 7 various chapters; chapter 1 is about the detailed introduction of the study with research objectives and questions. Subsequently, chapter 2 is about the detailed literature review that how previous studies looked into this important topic. Chapter 3 describes the study's detailed methodology and data description, as well as data gathering procedures and other important variables. The results of bivariate analysis have been discussed in chapter 4 i.e., about the farmer's awareness measured through the KAP survey. Chapter 5 is about in-depth interviews of government experts and stakeholders about manure composting. Chapter 6 is about the detailed cost-benefit analysis of bio-fermenter plants and other interesting revealed facts. Last but not least chapter 7 is about the conclusions of research and policy recommendations.

CHAPTER 2

LITERATURE REVIEW

2.1. Climate Smart Agriculture and Manure Composting

Climate-smart agriculture (CSA) is a comprehensive idea. It brings together several concerns connected to agricultural growth as well as other global development goals. Climate-smart agriculture (CSA), is an approach for transforming agricultural systems to support food security and other production challenges. Climate-smart agriculture is a pathway towards increasing productivity and income (Caba, Bordean, Matei, Matei, & Pavel, 2019).

Not only is agriculture one of the most critical sectors to the effects of global warming, but also directly responsible for 14 percent of global greenhouse gas emissions. Threats may be mitigated by strengthening farmers' adaptation strategies, as well as resilience and resource utilization in agricultural production systems. The CSA promotes farmers, researchers, and others to work together to take coordinated action.

The mitigation of climate change in agriculture (MICCA), the program expands the knowledge base on climate change mitigation in agriculture by conducting life cycle analyses of agricultural production chains, analyzing global mitigation potentials and costs, and reviewing farm-level mitigation opportunities and obstacles. FAO encourages agricultural, forestry, and fisheries operations that increase sustainable output while building agricultural ecosystem resilience to the effects of current and future climate change.

Numerous methods and technologies that can help to reach the objectives of study currently exist. Also, these methods have been thoroughly tested. Increased investments, however, are required to establish the institutional capacity to enable their adoption. Investments will also be required to solve knowledge and technological gaps to enable local adoption.

Composting is one of the major manure treatments that is commonly used as an alternative to traditional waste management in any agricultural practice. Manure composting may convert complicated organic substrates into hygienic and stable end products. Also, manure composting can be utilized as organic fertilizer to increase soil fertility and crop productivity. Composting has been considered as one of the very useful methods around the world to increase the yield of crops, by minimizing fertilizers intake.

2.2. Manure Management and Developing Countries

Manure has been used as a fertilizer since ancient times and if well-managed it can be an asset, promoting sustainable agriculture, and increasing crop production for farmers. However, most farmers do not use manure management practices due to unaware the efficiency of organic products in agriculture. Many studies have been identified that summarizes government policies that lift socio-economic and rural activities (Ndambi). In developing countries, a shift towards sustainable agricultural practices can deliver long-term food security as well as economic environmental social and cultural benefits. Also, in developing countries the impacts on livelihoods of organic farming always fetch higher prices than conventional products. However, in some cases, certified organic products end up being sold at higher prices and prices that influences the farmers planting decisions (Offermann).

In many developing countries like (Kenya, Malawi, Rwanda, and Burkina Faso, there was at least one ministry responsible for all of the activities of agriculture (Teenstra). These all countries successfully launched the agriculture sustainable policies and huge outcome seen in productivity and GDP contribution. The review confirms that potential of manure to improve crop yields and promote sustainable agriculture that is cost effective.

Policies in many developing countries do not explicitly mention livestock manure management, but responsibility is shared by different ministries of agriculture leading to incoherent policies, and abnegation of these responsibilities. Many studies have suggested that the enforcement of agricultural policies leading to conservation methods and new techniques are always suggested by agricultural departments of country (Lentz).

2.3. Livestock Manure and Environment

Greenhouse gas GHG's, emissions produced during usage of commercial fertilizers. (Peigné & Girardin, 2004). On the other hand, uncontrolled disposal of animal waste as well as causing environmental impacts, does not allow them to be converted into resources through the recovery of organic matter.

All South Asian countries have established numerous national policies, strategies, and plans to prevent soil and land degradation for sustainable agriculture practices. A sustainable agricultural system must be constructed on an approach that investigates the relationship between farming and other components of the social, economic, and environmental environment (Afzal, Naqvi, WFP, & Balochistan, 2004), Organic farming, as well as the

utilization of agricultural leftovers, compost, and animal waste, has gained popularity, although more work is required. Given the rising need for food production, it is critical to employ agricultural inputs.

When compared to fresh manure application, compost utilized in fields has fewer nitrogen losses. This approach is included in the notion of sustainable agriculture and is encouraged in organic agriculture standards (Godden & Penninckx, 1997). The composting process produces an easily spreadable, odor-free product that, due to the temperature achieved during composting, enhances the destruction of weed seeds and pathogens and allows animal dung to be transported longer and more readily than fresh manure.

Estimated ammonia and methane-air emissions from the waste of livestock are low as compared to the manure of livestock. They said that livestock waste is a minor contributor to methane and ammonia (Shih, Burtraw, Palmer, & Siikamäki, 2008). Findings have helped to understand the technical and economic relationship to realize the benefits of managing air emissions and agricultural waste discharges.

Another method that has been studied by (Reynolds, Padisák, & Sommer, 1993)to reduce ammonia volatilization is the use of slurry tanks or manure heaps. Plant nutrition changes in soils were strongly reliant on soil and manure amendment. The percentage of co-composted materials had a significant impact on the extractability of nutrients from soils modified with co-composted manure samples. Compared the effects of different surface coverings on cattle and pig slurry and concluded that the emission of Nitrogen was reduced with lids made of nylon foil, peat, or oil and straw.

Commercial fertilizers affecting the environment included the quality of water, air, and soil. The use of inorganic matter damages both soil and the environment. On the other hand, studies suggested that the composting of manure has been effective not only for soil but for the climate effects, reported by (Obikaonu et al., 2012).

The effects of composting on water pollution are less important than pollution, but they are not negligible. Several composting practices have a role to play in controlling the gas formation and release through leaching and runoff at different levels (Peigné & Girardin, 2004). Several health problems have occurred just because of the poor management of livestock and their waste. The share of enteric fermentation in livestock is more than 68 percent of the total share of methane in agriculture (Eghball, Power, Gilley, & Doran, 1997).

Composting of animal manure and tree wastes has the potential to provide numerous environmental and economic benefits. The primary rationale for using tree waste as a bulking agent is its widespread availability in urban areas. However, available nutrients undergo a range of transformations during composting process (Dahshan, Abd-Elall, Abd-El-Kader, & Megahed, 2013). The study was to look at nutrient availability in soils treated with cow dung co-composted with maple tree litter.

Manure is a source of nutrients for crops, but it also has many detrimental environmental effects. Such as effects on surface and groundwater quality, local air quality, and climate change. It invariably released ammonia (NH3) and greenhouse gases (GHG) such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), which not only decreased the nutrients in the final compost but also diminished the environmental benefits of composting. It is so critical to use this resource sustainably. The most recent scientific discoveries on these environmental issues, as well as alternatives for the sustainable use of manure as a natural resource according to (Dijak, McCann, & Brock, 2020).

According to (Sarwar et al., 2020), rural regions in Pakistan are controlled by the local government, which has a population of 2.8 million people. The government has implemented many schemes to reduce the intake of synthetic fertilizers but increasing year after year. It is roughly estimated that natural resource recycling could be a cheaper option to reduce the requirement of synthetic fertilizers throughout the country's demand. Composting is one of the many manure processing processes that may be used to enhance the management of animal manure (cattle, buffalo, horses, mules, camels).

2.4. Composting as Organic Fertilizer

Animal excreta (urine) and bedding materials are referred to as livestock waste and are utilized as organic fertilizers for agricultural usage. Animal manure may also contain wasted feed, and water, depending on the livestock management method. Livestock has been used from the beginning of agricultural techniques more than 80 centuries ago (Li, Kadav, Durdanovic, Samet, & Graf, 2016). Before the extensive manufacturing of synthetic fertilizers, animal dung provided the majority of external crop nutrients. The nutritional content of manure is made up of natural components that eventually contribute to plant production. These nutrients can be recycled in the natural environment.

Compost has piqued the interest of various animal manure management systems due to its cheap operating costs and significant social and environmental advantages (Liu et al., 2020).

Composting also has the advantage of decreasing direct manure usage and eliminating weed seeds and pathogens as a result, composting is highly suggested for manure treatment.

Currently, 45 processing approaches have been identified, each should be chosen with local limits and as well as various economic, territorial, environmental, and political settings (Foged et al., 2012). Composting is one of the many manures processing that may be used to enhance management. The biochemical mineralization of the organic component in composting lowered the volume of manure wastes. Composting might increase soil fertility, supply nutrients, and reduce the danger of diseases and weeds spreading.

Composting has long been regarded as the most favored technique for the safe disposal of livestock waste. Also frequently portrayed as a low-tech, low-investment process. A valuable supply of organic fertilizer is regenerated, and environmental deterioration may be reduced as a result (Anwar, Irshad, Ping, Hafeez, & Yang, 2018). Composting is a favored method of converting wastes and organic byproducts into more nutrient-dense end products. Increases or decreases in nutrient ions in soil were most likely directly related to either a concentration or dilution impact of increasing litter ratios. Soil amendment with co-compost would therefore increase macronutrient availability while decreasing trace-element availability.

2.5. The Environmental Impact of Fertilizer Use

Environmental and agricultural studies have repeatedly proven that intensive farming methods have contributed significantly to advances in global food production over the last several decades (Rahman, 2018). However, it has been shown that these intense agricultural methods have begun to change the farm environment, impede the flow of resource availability in agriculture, and lower agricultural productivity.

Soil deterioration and its economic consequences for farmers is one of the most pressing issues (Binaj, Veizi, Beqiraj, GJoka, & Kasa, 2014). They discovered the economic losses caused by soil degradation and the impact on farmers as a result of decreased production and an increase in fertilizer costs. They discovered that there was a huge loss owing to nutrient loss due to water erosion and yield losses due to soil compaction, with annual economic losses amounting to roughly 5.5 percent of agriculture GDP. In China effects of fertilizer use according to (Cann et al., 2002) on the environment and food production has been discovered that the concentration of nitrogen in the earth's 18 surfaces is growing,

concentration in groundwater, resulting in significant issues such as red tides and increased ammonia emissions.

According to many studies, fertilizer as an essential means of production plays an irreplaceable role in promoting the development of agricultural output. However, there are some issues such as excessive chemical fertilizer supplementation, blind replacement, undue emphasis on the substitution of synthetic fertilizers for crops, and the impact on soil quality (Dong et al., 2020). Contradictions such as the decrease of surplus fertilizer, food safety, resource depletion, and environmental degradation have grown more visible. Organic fertilizers have gotten a lot of attention because of their ability to improve soil fertility while still being environmentally friendly.

Manure undergoes biological breakdown during composting, resulting in a gaseous product according to (Wang et al., 2019). The results would be useful in understanding the gas emission characteristics of the composting process and serving as a guide in developing an aeration strategy with low GHG or major gas emissions while retaining high nutrient components in the final compost products.

Intensive usage of farm chemicals in high-yielding crop agriculture pollutes the farm environment, destroys natural ecosystems, and produces a slew of negative externalities. As a result, the negative environmental consequences limit a rise in agricultural productivity (Savci, 2012). Chemical-intensive crop damages on-site natural and environmental resources such as agricultural soil and water supplies, as well as pollute the atmosphere.

2.6. Fertilizers and Human Health

Environmental and health consequences of excessive chemical fertilizer usage are key issues. Soil salinity, and other difficulties linked with it, contribute to the greenhouse effect problem (Aggarwal et al., 2018) (Hubbe, Nazhad, & Sánchez, 2010). They discovered that there would be an increase in the nitrogen and phosphorus concentrations in drinking water and the river and that plants produced in high nitrate concentrations have been hazardous due to carcinogenic chemicals.

The impacts of soil nitrification and its impact on greenhouse gases have been discovered. Applying nitrogen and ammonia fertilizers to soil causes a high amount of GHG emissions, including nitrous and carbon dioxide gases (Kitagawa & Hauser, 2013). He discovered that applying ammonia fertilizer to agricultural areas produces additional nitrogen gases and that using ammonium nitrate fertilizer should be avoided. He also discovered that other variables

such as temperature and moisture impact nitrogen release, and that soil types such as waterlogged regions have been produced more efficiently.

The research is being carried out at Bangladesh Agriculture University, and the experiment is being carried out in a horticulture farm (Islam, 2017). According to the findings, blended fertilizers provide the greatest outcomes in terms of fruit measurement. Bangladesh, researchers studied the quality of fruits and tomato production using various types of inorganic and organic fertilizers.

2.7. Cost-Benefit Analysis of Manure Composting Through Livestock

According to research studies, manure enhances crop and pasture yields. It increases soil organic matter content, elevates soil pH, enhances nutrient exchange and water holding capacity, according to (Mclntire, 1989), adequate quantities continuously, may allow for steadily increased crop production.

To observe the economic and environmental issues, three conventional, organic cropping systems, with animal waste and without livestock waste were included in the experiment (Pimentel, Hepperly, Hanson, Seidel, & Douds, 2005). They discovered that organic farming was the best fit for farms. In the organic farming systems, soil organic matter was significantly greater than in the conventional system, which was more favorable for the sustainability of agriculture.

The effects of chicken manure on the productivity of spring maize are identified and used different levels of chicken manure to measure the yield of spring maize. By applying six different levels of manure to the field, and then collected the data through a standard procedure to measure the growth and yield parameters (Peigné & Girardin, 2004). The data are then statistically analyzed using Fisher's analysis of the variance technique and the standard deviation. They found that the yield from the highest level of manure is more than the lower, except for the number of cobs per plant that is not affected by it.

The results have shown that the biogas generation system through livestock waste in rural areas of Brazil has provided 12 economic benefits in the form of energy generation and environmental benefits in the form of animal treatment of waste. Brazil is a country rich in livestock waste, but the management of these resources is a major issue (Shepherd, 2000). There is no proper treatment plant for the management of animal waste, especially in rural areas (Peigné & Girardin, 2004).

In many types of research composting is identified as valuable and feeds virtuous cycles of soil recovery, restores fertility, and contributes to carbon sequestration in the soil. Additionally, reducing fertilizer, pesticide, and fuel inputs, lowers production costs and reduces the negative impacts of agricultural operations (Palese et al., 2020).

CHAPTER 3
METHODOLOGICAL FRAMEWORK OF STUDY

This chapter mostly pay attention on the conceptual framework, data description and methodology, data collection, and technique employed in the study. All of these are discussed below to achieve the study objectives:

3.1. Conceptual Framework

In our study, it has been assumed that livestock manure is a natural resource and asset for rural farmers. Previous studies have shown us that animal manure and its management can help the farmers transition to organic farming (Russell Neuman, Guggenheim, Mo Jang, & Bae, 2014). To meet the study's aims, it is believed that increasing farmers' understanding of manure composting and innovative agricultural practices may reduce production costs. Therefore, studies have shown us the already available methods and techniques on manure composting, around the world and other successful running projects on composting. For the sake of cost and benefit analysis, a bio fermenter plant and its cost of production per acre have been estimated. It is assumed that using livestock manure through proper management would increase the yield of farmers and minimize the cost of production. Manure composting is the new way to produce sustainably and believe that large farmers can be more interested if proper information and method explain to them about manure composting.

The farmer’s awareness regarding manure composting has been analyzed through the KAP, survey method. The survey has especially tried, on why these farmers use fertilizers despite having their livestock manure that can use as organic fertilizers. The study has also tried to know whether our government institutions are promoting organic agriculture in the country. The study also quantified how much money may be saved by providing farmers with adequate information on utilizing manure rather than fertilizers. Most farmers use animal manure in their seasonal crops; however, the existing method of employing manure is incorrect and contributes to weed infestation. The research framework is depicted in figure 1 below:

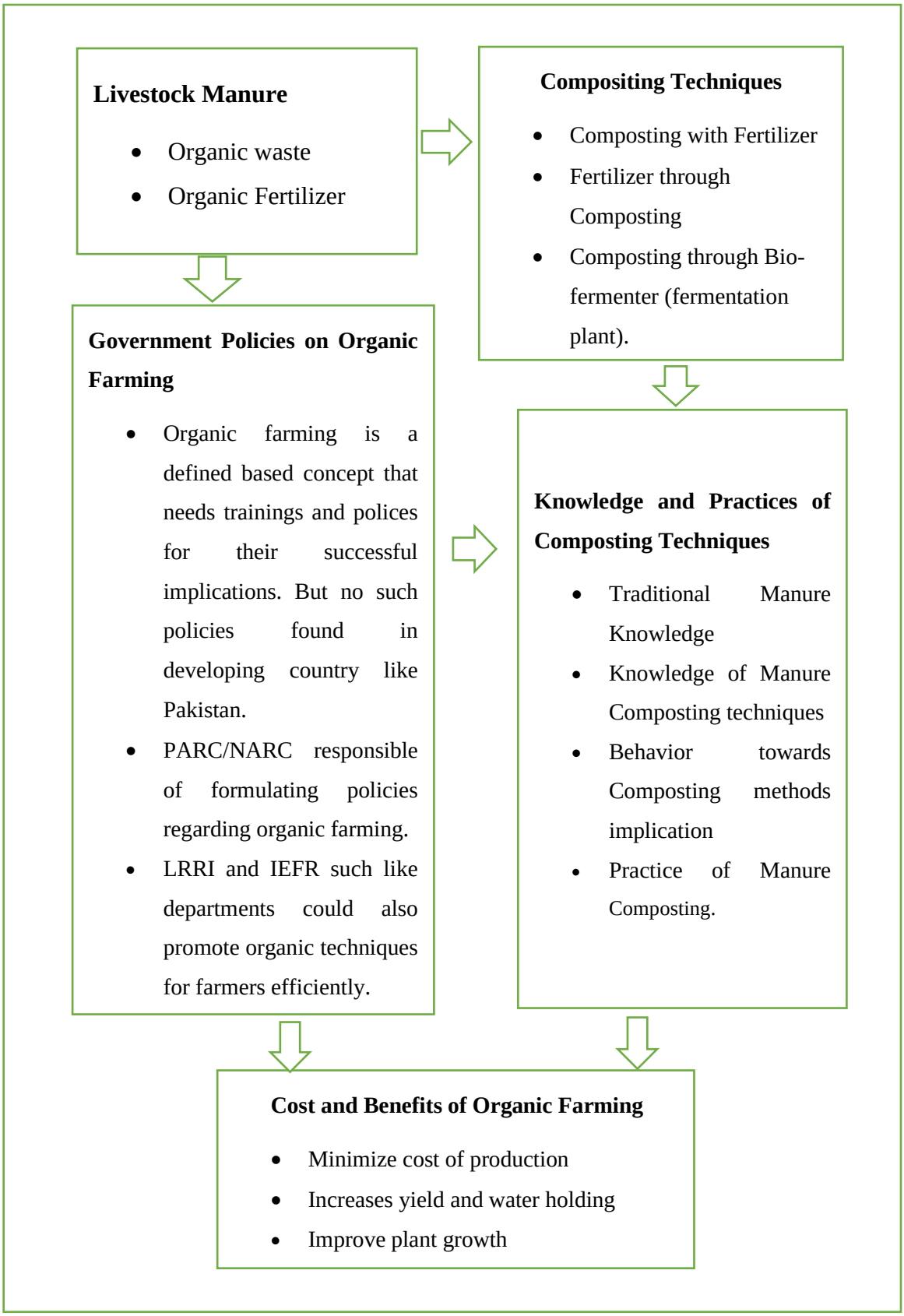

Figure 1: Conceptual Framework of Present Study. Source: **(Kumar S. N., (2018))**

3.2. Data Description and Methodology

This section of the study has concerned with data collection and methodology which are used for the analysis of the results. The first objective of the study has been achieved by conducting a primary survey of farmers. And, the farmers' awareness campaigns have been done through KAP, a survey method in three districts including Faisalabad, Vehari, and Pakpattan of Punjab Province, Pakistan. The primary data has been collected through a structured questionnaire, with a set of standardized questions and a fixed scheme through vesting agricultural institutions like (PARC), (NARC) and by review of literature. A structured questionnaire for farmers designed to know farmers awareness and their stance regarding organic farming in country. A detailed appendix has been placed at end of thesis.

The primary survey about farmers has been examined by using bivariate analysis to evaluate farmers' awareness related to manure composting. Moreover, Excel and STATA tools have also been used to examine the further results of bivariate analysis. The below sections provide thorough information on several variables related to farmers' awareness:

3.2.1 Variables Description

a) Dependent Variable

Familiar of Composting

In our study familiar composting is the dependent variable and estimated through the binary response. The study estimated that if farmers know manure composting, the value "1" should be used otherwise "0".

b) Explanatory Variables

In the collected data variable familiar of composting represent the knowledge of farmer about manure composting or organic farming. The different explanatory variables have been used in the study to determine factors that influence the awareness of farmers. The details are as follows:

i. Age of Farmer

The age of the farmer plays an important role in determining his knowledge about manure composting. The age of the farmer has been determined between 22-65 years in several years.

ii. Education of Farmer

Education has been considered a crucial aspect for farmers to learn about manure composting. The education of farmers has taken under three different groups of education like primary, matric, and Bachelors'.

iii. Knowledge about Manure Composting

Visited manure composting plant represents the knowledge of farmers about organic farming. In this study visited manure composting plant has taken as a binary variable with knowledge. If the farmer has visited the manure composting plant, then take the value "1" otherwise "0".

iv. Source of Information

The study has calculated the farmer source of information with the dependent variable of the study. The farmer's knowledge about manure composting has been measured through the newspaper, another farmer, and Tv/radio.

v. *The Behavior of Farmer Towards Manure Composting*

The behavior or attitude of the farmers has been measured with the dependent variable familiar with composting. The attitude of fa farmers with composting knowledge has been measured through binary response takes the value "1" otherwise "0".

vi. The Practice of Farmers Regarding Manure Composting

The adoption or installation of a new technique by farmers has been analyzed through two important variables, knowledge of farmer and practice of farmer. The practice of farmer is has analyzed through binary response take the value "1" otherwise "0".

Information has been based on both secondary and primary data to achieve the study's second objective. The policy of government institutions has been reviewed by using secondary data. In a review of policy, a study has tried to know the initiatives taken by government institutions in promoting organic farming. Also, to absorb whether any policy exists related to organic farming in the country or not. In primary information of study, experts of government agricultural institutions have visited various sites to understand the challenges and constraints related to organic farming in the country. Following are the institutions:

- Pakistan Agricultural Research Council (PARC),
- National Agricultural Research Centre (NARC),

- Food and Agriculture Organization (FAO),
- Land Resources Research Institute (LRRI),
- National Rural and Support Programme (NRSP).

The qualitative data from experts have been collected through in-depth interviews and with the help of a semi-structured questionnaire. In the semi-structured questionnaire, the interviewer has asked only pre-defined questions related to organic farming. The reviews of policy and experts' opinions related to organic farming have been analyzed critically to achieve the study objective.

The third objective of the study is related to the cost-benefit analysis of manure and fertilizers. The study has been based on primary and secondary data. In secondary data of manure potential and fertilizers data of different crops like wheat, rice and maize have been collected through published reports. The remaining secondary data has been collected through record-keeping government departments like the Pakistan Bureau of Statistics (PBS), the National Fertilizer Development Centre (NFDC), the Agricultural Marketing Information System (AMIS), etc.

The primary data of the study has been collected through different stakeholders, farmers, and experts. The primary information like variables cost, maintenance cost, size of the plant, cost of manure, cost of production per acre, and yield benefits have been collected through a semi-structured questionnaire. In the semi-structured questionnaire, the interviewer has asked pre-designed questions related to organic farming like variables cost and maintenance cost, etc. The detailed appendix is located at the bottom of the thesis.

After explaining the study objectives, expert of (IEFR), Rana Naqshband explained manure composting and their enormous benefits in terms of cost and production. Also, the expert explained and elaborated formation of bio-fermenter plant in terms of cost effective and helps to increase production. Furthermore, he explained and provided all the necessary measurements and information as necessary for successful formulation of plant. Fixed and variable costs have been confirmed through already available plants in area. Principal scientific officer Dr, Razaullah (PARC), explained current status and initiatives of organic farming that helps a lot research in policy recommendation. Another, scientific officer Dr, sultan Tariq from (NARC), helped and explained whether composting experiments are successful or not, also fixed other queries related to organic farming. (FAO), research officer

helped to find what are their contribution in the country for organic farming. The experts listed in table 2 have been interviewed.

Table 2: List of Experts

Name	**Institution**	**Designation**
Dr.Sher Muhammad	(AIOU)	Chairman Agricultural Sciences
Rana Naqushband	(IEFR)	Research officer
Dr. Raza Ullah	(PARC)	Principal Scientific Officer
Dr. Sultan Tariq	(NARC)	Principal Scientific Officer
Dr. Imtiaz Ali	(FAO)	Research Officer

3.2.2 Cost and Benefit Analysis of Manure Composting Plant

In this section, cost and benefit analysis has been performed to calculate the cost differences between fertilizers and manure composting plants. The cost and benefit analysis has also been determined by identifying costs and benefits associated with the manure composting plants. Assigning values to them, calculating future benefits, and determining the project's financial viability all are part of the process. Among many manures treatments composting is widespread process and showing huge potential. Manure composting has been considered effective for every type of farms like very small, small, medium, and large.

For the purpose study has considered four types of plants as 2-acres, 6 acres, 12 acres, and 24 acres for the usage of farmers. The manure data has limited availability and due to concern study has performed fixed cost investment of plant for 15 years. For the internal rate of return IRR and net present value NPV, techniques have been used in the study. One of the prime goals of this research is to achieve the economic and environmental benefits of manure composting plants. There is no doubt that manure composting plant is an excellent and viable economic and commercial option for farmers. The primary data of manure composting plants have been as follows:

- Shadow prices (like the estimated price of manure sold in the village etc.)
- Size of the plant (manure composting plant installed for utilization per acre land)

- Life of the plant (it involves the duration of plant-like how long it will work for farmer)
- Labor cost (labor cost help us to identify, how much cost is required to run the plant)
- Variable cost (operational cost involves microbes cost, and water cost to prepare the fertilizer through manure composting plant).
- Maintenance cost (maintenance cost is estimated to know the damage recovery of the plant).

The above-mentioned all variable costs have been collected through stakeholders and farmers in the areas of Punjab Province. The detailed information has placed in appendix-2 at the end of the thesis. The standardized project evaluation technique is used to investigate the feasibility of a manure composting plant. The profit from the manure composting plant has been calculated by using the standard profit formula (revenue-costs). The project feasibility indicators, such as the benefit-cost ratio (BCR) and the internal rate of return (IRR) are estimated, and information is provided below. The operational costs (labor, equipment, manure cost) and benefits are estimated for the project's life cycle and converted into present value. The detail of costs and formula to estimate the net value is given below equation (4).

$$A\pi_{i=1}^{4} = \sum_{i=1}^{2} \mathrm{APFQ} + \mathrm{PAC} + \mathrm{APB} - \mathrm{MC} - \mathrm{OPC} - \mathrm{OCM} - \mathrm{AFC}. \qquad (4)$$

Where:

i =Size of the plant

$A\pi_{i=1}^{4}$= Average profit for the size of manure composting plant per annum

ABFQ= Average benefits shifting from fertilizer to manure composting plant

PAC= Price of carbon emissions and the average quantity of carbon emissions

fertilizer used by farmers per annum

APB= Average productivity benefits from manure composting plant

MC= Microbe's cost consumed in the manure composting plant per annum

OPC= Operational cost used in manure composting plant per annum

OCM= Opportunity cost of animal manure used by farmer per annum

AFC= Average fixed cost of the manure composting plant.

i. Measurement of Plant Size

The current study has calculated the average net profit for an individual by using the same plant size. As four sizes of plants have been taken in our sample, the average net profit for each size has been estimated separately. The total sample size has been divided into four groups of manure plant users: very small 2acre, small 6 acres, medium 12 acres, and large 25 acres. Net present value and internal rate of return have been measured through the equation given below (5).

$$NPV = \sum_{t=1}^{n} \frac{rt}{(1+r)^t} \qquad (5)$$

Where:

Rt= Net cash flow in a single time period (t)

r = discount rate or return rate that could be earned in alternative investment

t = number of time-periods

Equation (4) has used to calculate the net present value. If the (NPV) is zero, then r equals the internal rate of return. By using the above equation, a study has calculated the Internal Rate of Return (IRR). The benefit-cost ratio calculated the return on each rupee invested on establishing a manure composting plant. The benefit-cost ratio (BCR) has been calculated by combining the present value of the benefit and the cost**.**

ii. BCR, Benefit present value / Cost present value

BCR has defined as the rate of return on investment. Our study has analyzed plants for 15 years, depending on the project or the estimated life of manure composting plant from the survey.

3.3. Sample Size and Sampling Technique

Survey awareness of farmers has been performed through structured questionnaires with a sample size of 150 households. The study has considered only large livestock households. The survey has conducted through an android phone application, using Microsoft forms rather than a paper questionnaire. Due to time constraints, purposive sampling has been employed in this study with 50 households selected from each village in three districts.

The first village visited for data collection is 7G-Ghag in the district of Jhang, tehsil Shor-Kot. The second village is 191/EB in the district of Burewala in South Punjab. Similarly, the third and last village visited 255/WB in the Pakpattan district. To address farmer

difficulties, the farm size has been classified into three categories: small farm, medium farm, and a large farm.

3.4. Questionnaire Design

A good questionnaire should address the research in a sequence according to the objectives of the study. In our study farmers and their constraints to adopting the new techniques and methods in agriculture have been identified through a structured questionnaire.

a) Respondents Profile

In section (A) of the questionnaire, the questions were about the province in which data has been collected, the district and name of the province, the name of the respondent, year of birth, years of schooling, and the mobile number if available is mentioned.

b) Manure Knowledge of Traditional Farmers and Awareness of Composting

In section (B) of the questionnaire, the questions have been asked to the respondents about livestock manure and its usage. Questions related to total land of the farmer as he has to cultivate including own/rent or sharecropping.

In section (C) of the appendix, questions have been asked about the knowledge of farmers about manure composting. For better understanding proper questionnaire has been placed in the Appendix at end of the thesis.

c) Cost of Crops

In this section of the questionnaire, the respondents of the study have been asked about the major crops sown in season. Also, about the major cost of production through different user inputs. In section (D) of the appendix different costs of crops have been discussed for example preparation cost and likewise.

3.5. Procedure of Interview Farmers and Data Entry

All the data has collected through face-to-face interaction and took three weeks in the field. However, it has significantly reduced the possible errors due to my concern for this study. The core intent of each question has been explained and discussed. Then the farmers have asked to respond according to their best knowledge. The data entry has done through excel software and converted into STATA software, where further statistical analysis has been performed. Data collection has been the toughest part of the research along with the meeting expenses, especially for a student in rural areas of different districts of Punjab.

CHAPTER 4

FINDINGS FROM KAP SURVEY

4.1. Introduction

This chapter consists of a bivariate analysis of the study between the dependent variable familiar with composting, socio-demographic factors, and the KAP survey method. The study has considered only the large livestock households in three districts of Punjab, Pakistan. The study has also mainly aim on determining farmers' awareness of manure composting in their respective villages.

The study has examined the farmer's natural resource manure of livestock usage by the inappropriate method. Many studies have suggested that the method of using livestock manure directly into the fields is considered to be unhealthy for soil and production. This type of method might increase the infestation of weeds and pesticides in the field.

4.2. Socio-Demographic Factors

Cross-tabulation of many key variables has been addressed in this section. Our study has enlightened the relationship of all collected data using different variables.[1] The purpose of the analysis through the KAP, survey method has provided us the main understanding of farmers about organic farming. Also, farmers' adaptation, main barriers, and reasons behind shifting towards organic farming. Farmer's knowledge as familiar with composting has been considered as the dependent variable. The other key independent variables are as follows; the age of the farmer, education of farmer, knowledge of farmer, source of information[1] farmer behavior[2], and the practice of farmer all are discussed below.

[1]Information source for farmers like radio TV, other farmers, NGOs, etc.

[2] Attitude of farmer towards manure composting

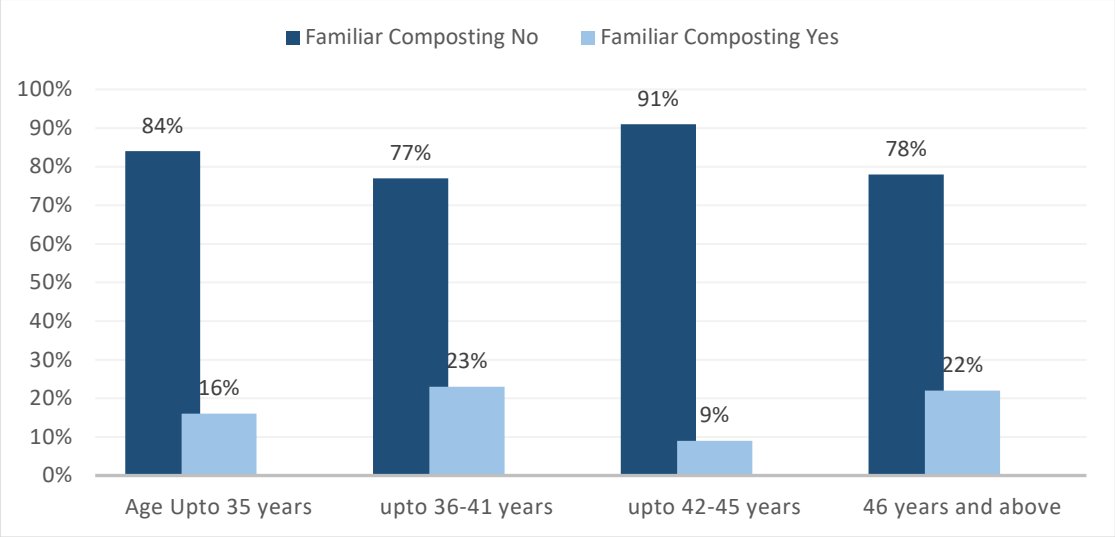

Figure 2 Farmers percentage distribution about familiar composting with age group.

Figure 2 shows, the percentage of farmers' knowledge about manure composting according to their age group. The x-axis of graph represents percentage of farmers regarding awareness and y-axis represent age of farmer taken up to 46 years or above.

As the above graph represents that farmer up to age of 35 years, only 16 percent knows about the manure composting technique, and the rest of 84 percent do not know. Similarly, in the age group of 36-41 years, twenty 77 percent have no familiarity of composting with 23 percent having knowledge. On the other hand, age group of 42-45 years 91 percent of rural farmers do not know, and 9 percent know that the manure of livestock could be used as fertilizer. Furthermore, in the last group of age above 45 years, only 22 percent of farmers have been familiar with manure composting and the rest of 78 percent have no familiarity.

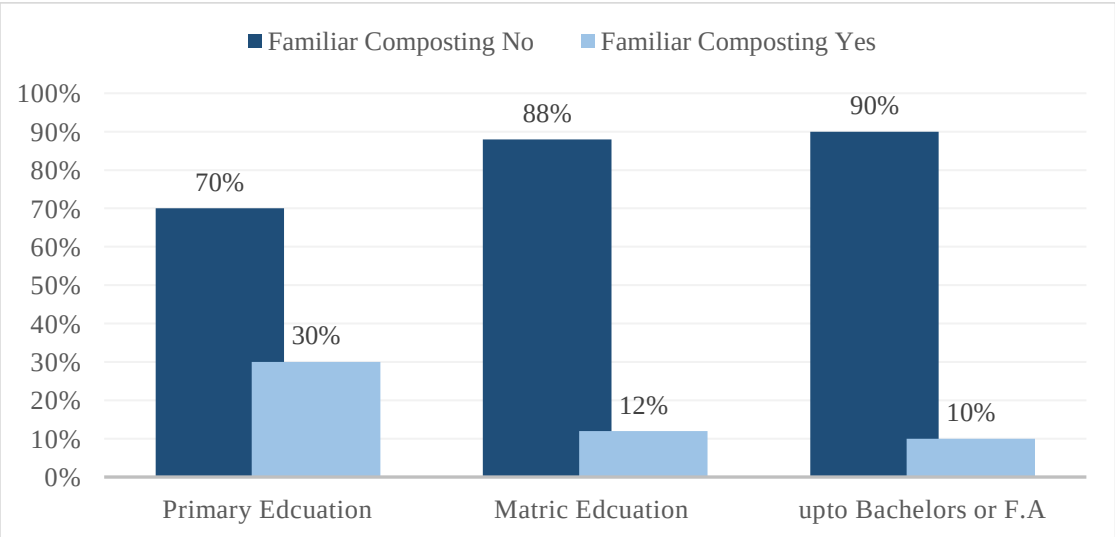

Figure 3 Farmers percentage distribution about familiar of composting with education.

Figure 3 shows the relationship of the farmers about familiar with composting with education and to identify the effect of the adoption of new methods and processes in organic farming. The x-axis of graph represents percentage of farmers regarding awareness and y-axis represent education of farmer taken up to bachelors or above.

According to the data, 70 percent of farmers with primary education are unfamiliar with manure composting, with only 30 percent having expertise. Similarly, 88 percent of farmers do not know about manure composting, and the remaining 12 percent know. In the last group of farmer education, only 10 percent of farmers have been familiar with the composting techniques, and the other 90 percent of farmers do not know.

4.3 KAP Survey Method

In our study KAP, a survey method has performed to know the relationship of different factors that influenced farmers' awareness regarding manure composting. The detail of different variables are as follows:

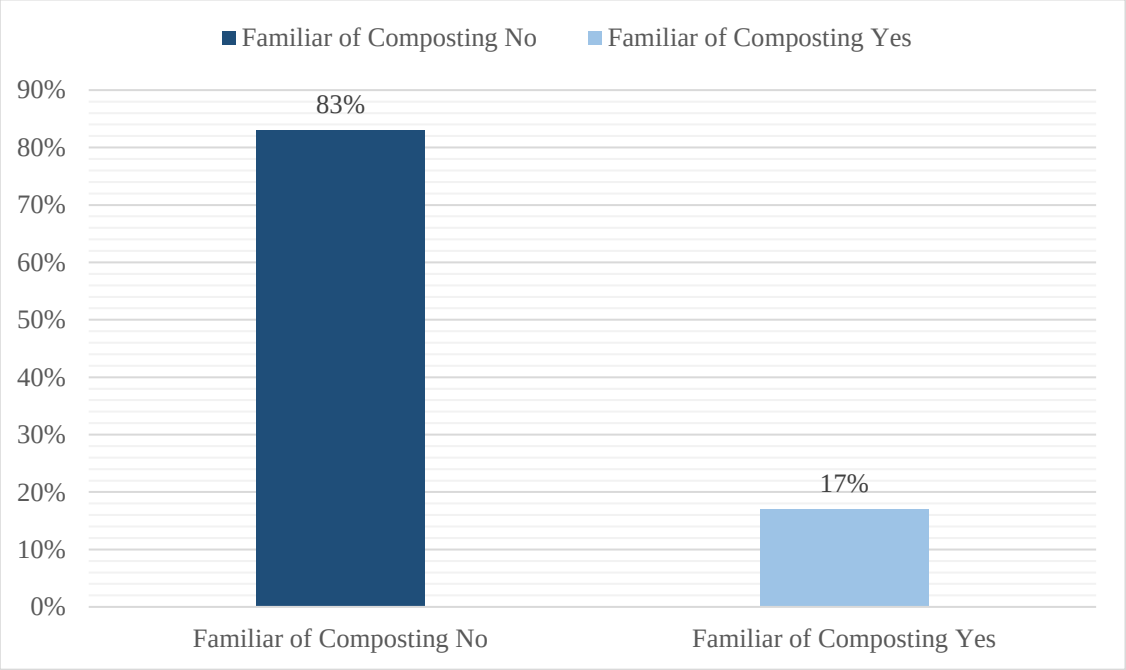

Figure 4: Percentage distribution of farmer knowledge about manure composting.

The study's bivariate analysis has been carried out to determine the association between various elements of farmer awareness. The x-axis of graph represents percentage of farmers regarding awareness and y-axis represent knowledge of farmer related manure composting.

Above table 4 depicts, 83 percent of farmers have no idea about manure composting. On the other hand, only 17 percent of farmers have familiarity related to manure composting techniques.

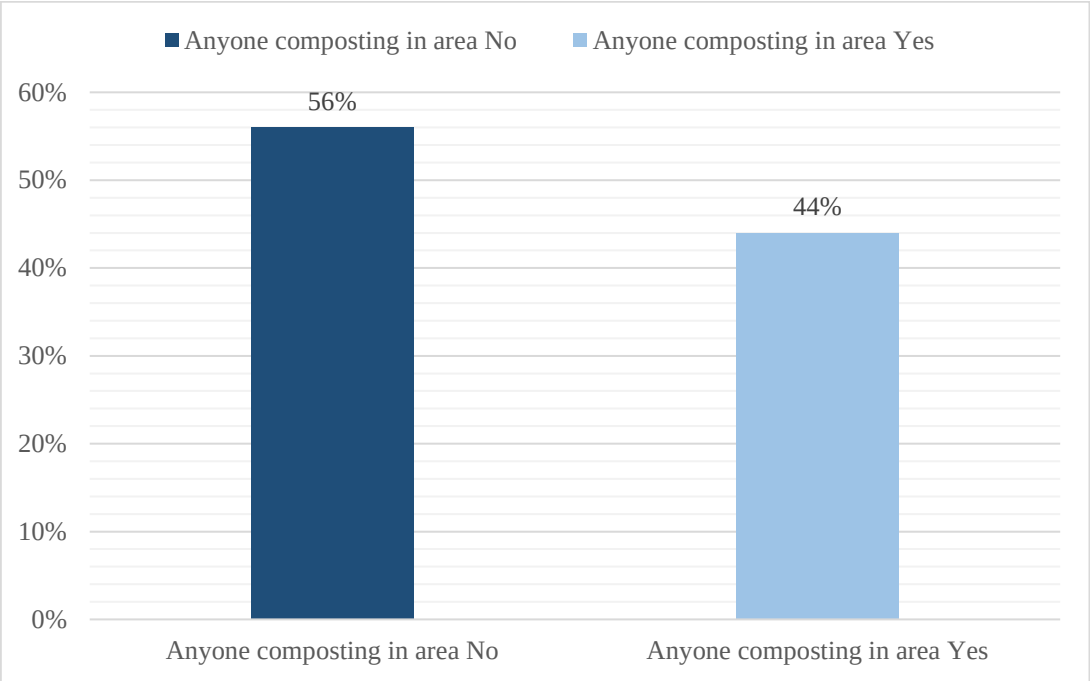

Figure 5: Percentage distribution of farmers' knowledge, if anyone composting in area.

The x-axis of graph represents percentage distribution of farmers and y-axis represent, if anyone composting manure as fertilizer in relevant area. Figure 5 reveals, that among 17 percent of educated farmers about manure composting, only 44 know about composting in their respective regions. While 56 percent have no idea whether someone is composting in their area.

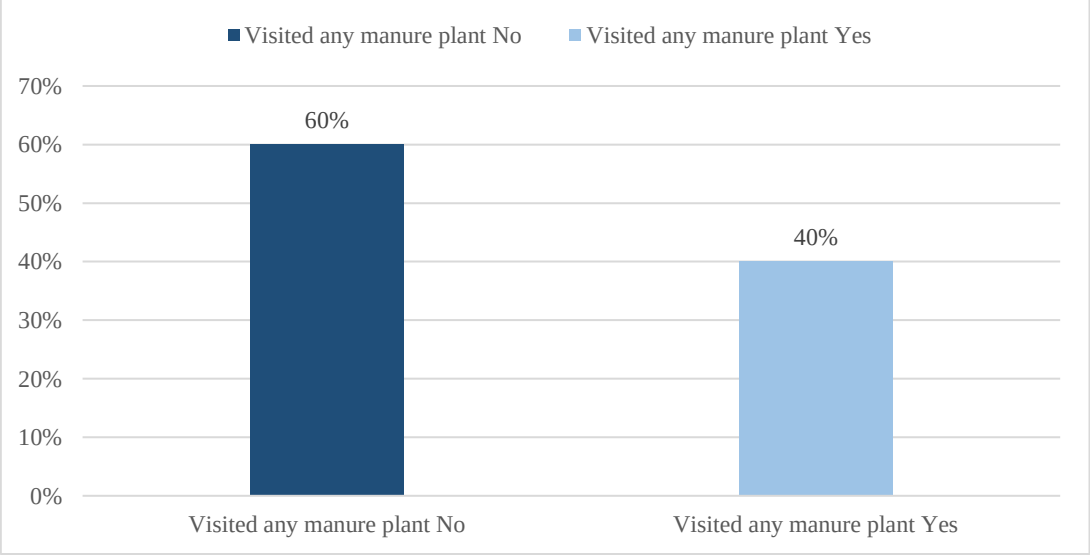

Figure 6: Percentage distribution farmers' knowledge, if visited manure composting plant.

The x-axis of graph represents percentage of farmers and y-axis represent knowledge of farmers, if anyone visited manure plant in relevant area. Figure 5 shows, that only 40 percent of farmers who have been familiar with manure composting visited the composting plant. On contrary to that, 60 percent of farmers remained uninterested to visit the plant.

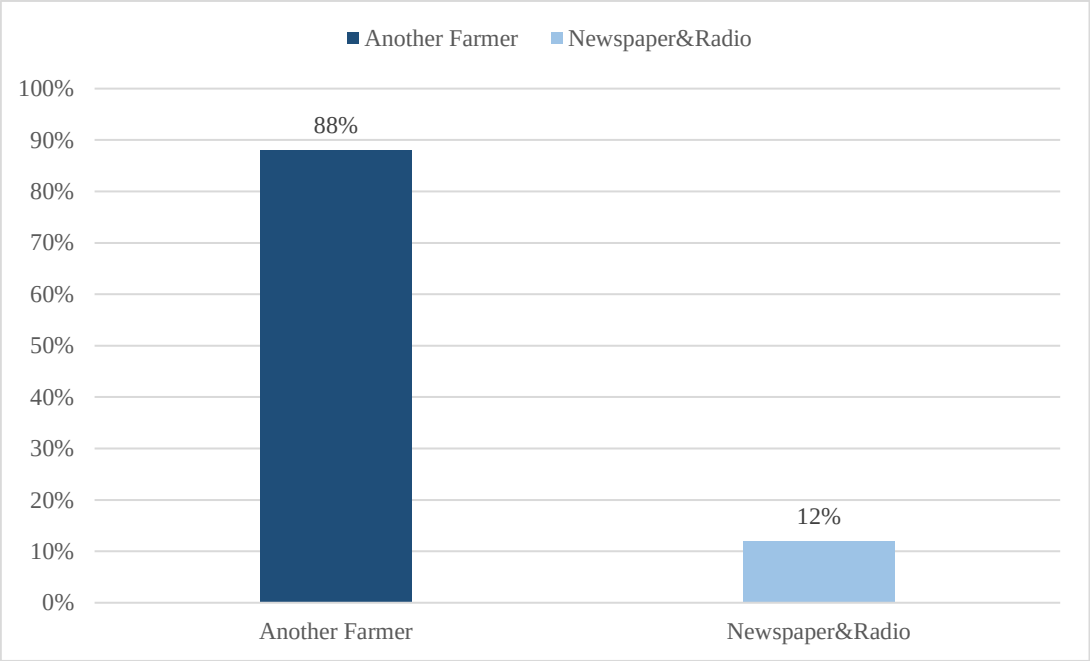

Figure 7: Percentage distribution of farmer knowledge with source of information.

The x-axis of graph represents percentage of farmers regarding knowledge and y-axis represent farmers source of information about manure composting. Figure 7 indicates, among the knowledgeable farmers about manure composting, 88 percent know another farmer. while only 12 percent have acquired information from media such as radio or newspapers.

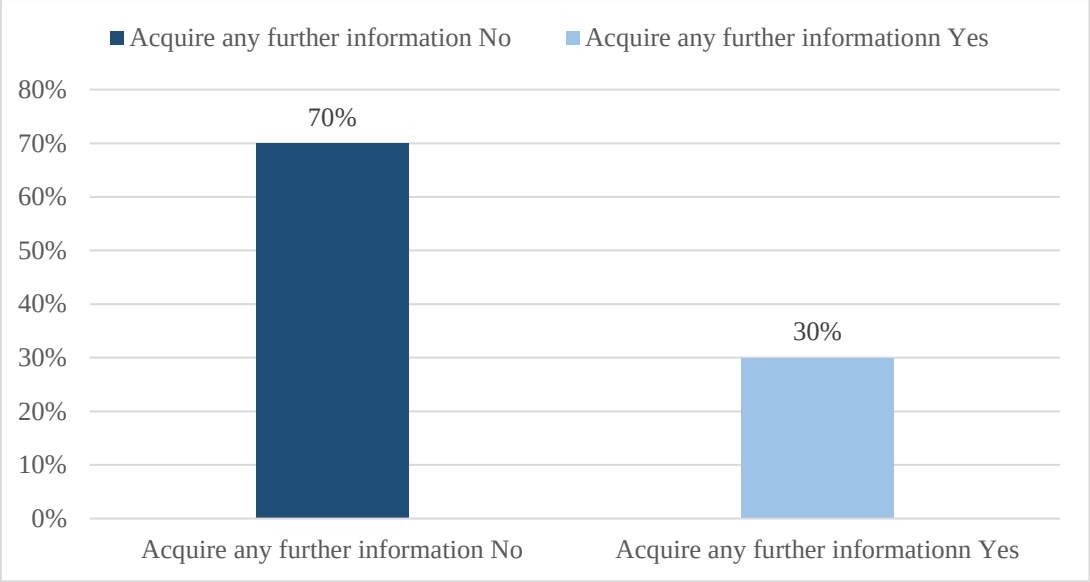

Figure 8: Percentage distribution of farmer behavior about manure composting technique.

The x-axis of graph represents percentage of farmers and y-axis represent if any farmer acquires further knowledge about composting. Figure 8 shows, farmers' reactions after understanding organic farming. According to findings, 70 percent of farmers acquired no further information about manure composting. However, in our survey, 30 percent of farmers learned more about manure composting techniques.

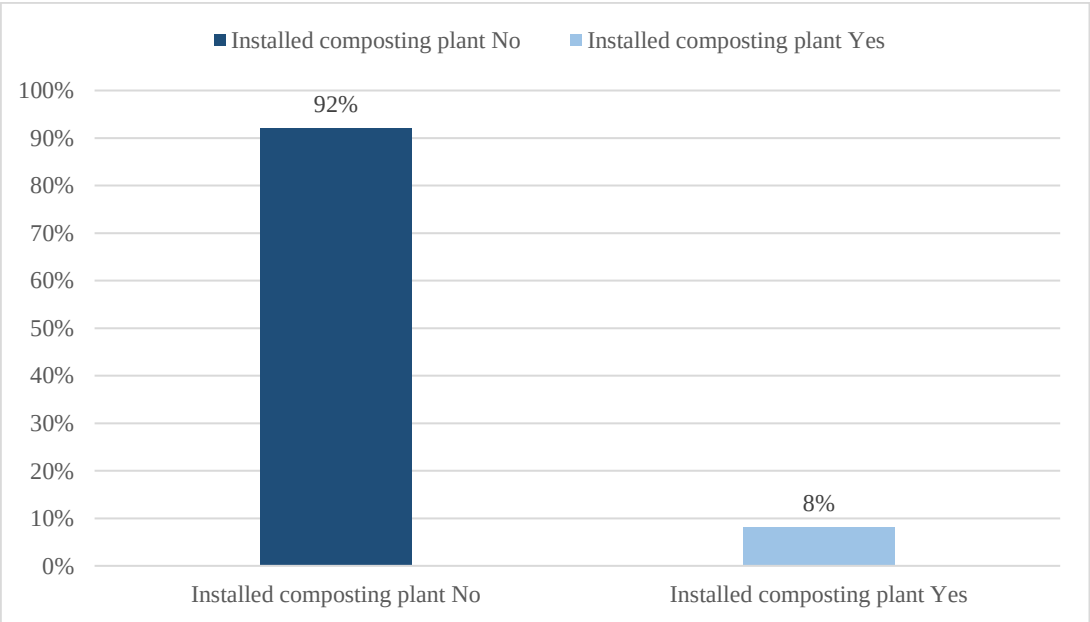

Figure 9: Percentage distribution of farmers' practice, related to manure composting.

The x-axis of graph represents percentage distribution of farmers and y-axis represents the practice of farmers regarding manure composting technique. Figure 9 indicates, knowledgeable farmers and their practice regarding manure composting. Subsequently, only 8 percent of farmers have installed the composting plant with 92 percent of farmers no installation.

CHAPTER 5

SUPPLY-SIDE ANALYSIS AND FINDINGS

5.1. Introduction

The main concern of this chapter is to weave up the overview of existing policies, initiatives related to organic farming in Pakistan. This chapter has also discussed the analysis of experts' opinions and feedback on their understanding regarding organic farming. Agriculture and livestock are federal as well as provincial subjects. Formulation of policy related to organic farming is the responsibility of federal government institutions and other agricultural ministries. The expert's views related to organic farming have been collected through visiting different government institutions such as PARC/NARC, LRRI, FAO, and AERI. These mentioned institutions have helped us in understanding current organic farming and manure composting methods and techniques.

5.2 Policy Review and Experts Views on Organic Farming

In Pakistan, there are two main bodies PARC and NARC responsible for research and new initiatives in agriculture system of Pakistan. However, for policy implication ministry of national food security and research MNFSR, is responsible. Also, to make country food secure by using less inputs these ministries play and important role. By analyzing the data through in-depth interviews study has observed, there is no policy and programs available for organic farming in the country.

Whereas the fertilizer policy was announced by the government in 1989, assuring the responsible prices of fertilizers. The present policy has been encouraging investors to enhance the production and import of fertilizers. Keeping in view the study has analyzed, a need is felt to update policy due to the increasing demand for fertilizers year after year.

As a result, farmers are employing large amounts of commercial fertilizers to improve productivity and output while damaging soil efficiency. These existing practices and methods have created an alarming and difficult situation for future generations. Government must put light on the important sector of the country, through proper initiatives and training programs.

Organic farming in agriculture, according to experts, is not a government priority. The government has not been interested to invest or subsidizing the sector through natural resource methods and their usage on farmlands. Rather than shifting via natural resources, the government encourages the manufacture and import of inorganic fertilizers.

The government's negligence may be seen in the fact that our national organic agricultural center has closed due to poor concerns. The disruption in the agriculture sector is the result of inadequate concerns and a lack of policy. According to experts, the constraints associated with promoting organic farming have a big challenge.

All private fertilizer industries have found against organic farming since they gain more profit than switching to organic farming. The private industries of inorganic fertilizers have big players in the bureaucracy, ministries, and they are good enough in fraudulence approach. By adding expert said, several times his department has shown serious concerns of organic farming country, but always refused by the government. There has been no policy until the government considers the subject of organic farming as a serious concern and recommends it to related departments.

Nevertheless, the study has suggested that policy for organic farming must be designed in the country. Along with other necessary factors like accountability, implementation, rules, and regulation. Otherwise, for future generations, there would be no more fertile and healthy soil. Also, agriculture promotions of organic farming must be addressed like compulsory teachings to farmers in the country.

5.3 Types of Manure Composting

Recent studies have suggested almost 50 methods to prepare compost on farmlands, including general compost of green manure, poultry manure, livestock manure, and composting through the bio-fermenter. Only two methods of manure composting have been considered in this study out of numerous. Also, farmers may easily adopt these methods and minimize the cost of production with other benefits Agriculture experts associated with PARC/NARC, have explained and elaborated the useful methods of composting as mentioned below.

a) Composting through Water

The experts have explained different composting techniques, among many composting through fertilizer has considered a useful method to produce organic fertilizers. Farmers can prepare their compost by making a window row of 3-4 feet in width and 5 feet high, and the

manure level of moisture must stick to 50-60 percent. Farmers require water in this manner and change the position of manure using machinery in large areas or with a spade in small areas. However, this is a time-consuming technique, and farmers in a nation like Pakistan have a limited amount of time to manage all of their crop production demands. Composting through fertilizer has mentioned below in figure 6. Fertilizer produced through managing manure by window row has the following disadvantages.

- Susceptible to weather and regular change of manure place
- Difficult to maintain and require equipment to change place
- Preparation of fertilizer need three months with more space
- Transportation issues and low yield

Figure 10: Organic Fertilizer Through Managing Manure (3-Months)

b) Composting through Bio-Fermenter Plant (fermentation plant)

Manure composting through the bio-fermenter plant is extremely useful to farmers and a cost-effective process also called a low-cost fertilizer factory. Nonetheless, microbial technologies have successfully applied to a variety of agricultural and environmental challenges in recent years. Furthermore, (bio-fermenter) plant has a simple method to generate its fertilizer on the farmlands mentioned below in Figures 9 and 10. Moreover, bio-fermenter manure composting plant has the following advantages:

- Low construction cost
- high durability
- no need for skilled labor
- Construction provides opportunities for local farmers
- easy to maintain high yield
- Fertilizer produced in 7 days.

Figure 11: Production of Fertilizer in 7-Days Through (Bio-Fermenter Plant)

Figure 12: Farmers Using Fermenter-Plant of Manure Composting Successfully.

Table 3: Summary of the whole chapter

Study Findings	**Existing Policy**	**Experts View**
The import and production of commercial fertilizers have increased in the last few years. Due to the excessive use of commercial fertilizers, soil fertility has been damaging.	The existing policy for commercial fertilizers has announced in 1989. Assuring investment to enhance domestic production and import of fertilizers.	Synthetic fertilizers have damaged the soil's health and essential nutrients. Also, the production and yield of crops have decreased in recent years. The only solution is to turn the situation through organic farming.
No programs and initiatives are available for organic farming in the country.	There is no existing policy for farmers' training and conservation methods, related to organic farming in the country.	According to experts, organic farming is a highly recommended solution to produce, cost-effectively and sustainably.
Manure composting techniques like composting through the bio-fermenter plants is a cost-effective and useful tool in agriculture.	There is no policy regarding new technologies in agriculture in Pakistan.	The government experts approved manure composting through the bio-fermenter plants, as a low-cost fertilizer factory for farmers.

CHAPTER 6

COST-BENEFIT ANALYSIS RESULTS AND DISCUSSION

6.1. Introduction

This chapter discusses the full results of a cost-benefit analysis of a manure composting plant. The study has determined, the overall difference between costs of manure and commercial fertilizers. Both primary and secondary data have been used to calculate the manure potential and effectiveness of manure composting plants. The primary information related to manure composting plant (bio-fermenter), has been verified through experts, farmers, and stakeholders. Crop production and other relevant benefits have gathered during a meeting with farmers. Secondary data has also been considered in research to calculate the total area under fertilizers, production, and livestock according to provinces. The manure potential has been calculated through secondary data at the national level.

The analysis of composting plant (bio-fermenter), has been discussed through different variable and fixed costs. The variable costs include labor, maintenance, microbes, etc. The fixed cost of the plant has been considered as the initial cost for the farmer to invest for a single time, including all the benefits. Plant benefits have been converted into monetary values by multiplying them by their market prices and added to obtain total benefits. These all are discussed below in table 6.

Table 4: Fertilizer used Area, Consumption, and Local Production in Pakistan

Province	**The area under fertilizer uses 2011-2012 (million hectares)**	**Consumption of fertilizers 2013-2014 (000 tones)**	**Import of fertilizer The fiscal year 2020-2021 (000 tones)**
Punjab	12.52	2803.9	6375
Sindh	5.18	923.1	2230
KPK	1.88	226.5	404
Balochistan	2.49	135.6	381
Total	22.07	4089.1	9390

Source: Pakistan Bureau of Statistics (PBS) & National Fertilizer Development Centre (NFDC)

Table 4 has identified the overall area under fertilizers and their consumption in each province. According to economic survey of Pakistan 2020-2021, import of fertilizers has increased from 1.1 million tons to 2.6 million tons from 1990 to 2010 in the country. Almost the rise in the import of fertilizers has reached up to 1.5 million tons in the last twenty years. The total production of fertilizers has increased from 2.6 million tons to 6.4 million tons, with a rising of 3.8 million tons in the production of fertilizers. The reforms must be introduced in the country to address the core issues of imbalance usage of fertilizers in agriculture. Therefore, the study aims to reduce the consumption and import of fertilizers, and their harmful effects on the soil as well as on the environment.

Table 5: Livestock Manure Potential and Urea Fertilizer

Province	**Livestock Number (Million heads)**	**Annual Manure production (Million tons)**	**Annual Urea fertilizer production (Million tons)**	**Potential to produce urea through composting (Million tons)**
Punjab	32584	297329	2231	118931
Sindh	14608	13329	563	53319
KPK	8103	73938	206	73939
Balochistan	3020	27557	101	11023
Total	58315	53212	3101	2572136

Source: Livestock Census 2006 & National Fertilizer Development Centre (NFDC)

Table 4 demonstrates the country's vast cattle potential. The research used secondary data to assess the situation. If animal manure and urine are properly managed, 50 percent of the country's fertilizer needs may be easily satisfied. The study distinguished between annual synthetic urea production and possible urea generation from animal urine through composting. Very basic computation of animal manure and urine has been done to determine the generation of urea fertilizers. According to data on animal husbandry large livestock like cows and buffaloes, produced 25 kg of manure each day. The yearly manure production for Punjab and all other provinces has been determined by multiplying 25 kg of manure generated each day with total livestock. The obtained result has multiplied with 365 total days in a year to obtain annual manure production e.g., (25*32584*365=297,3290,00).

The rate of animal excretion has been collected through expert of animal husbandry in university of agriculture Faisalabad. The yearly urea production for Punjab and all other provinces has been determined by multiplying 10 kg of urine discharged by a large animal with a total livestock population. The obtained result has multiplied with 365 total days in a year to obtain annual urea production e.g., (10*32584*365=118931600).

However, every year, a large quantity of animal natural resources has been lost in the country, owing to a lack of understanding and the availability of innovative conservation methods in agriculture. Our only chance to reverse our soils and produce sustainably is through livestock. Subsequently, the government must acknowledge such great potential of livestock and transform Pakistan's agriculture into more productive techniques.

Table 6: Farmer Cost of Production (through fertilizer and manure composting)

Major Crops Produced through Manure composting plant and Fertilizers	**Farmer Cost of Production under Fertilizer (Per acre) (Per Pkr)**	**Farmer Cost of production under manure composting plant (per acre) (Per Pkr)**	**The cost saved through manure composting plant (Per acre) (Per Pkr)**	**Percentage cost saved through manure composting plant (Per acre)**
Wheat	43399	34577	8822.00	20%
Rice	53698	44000	9,698.00	18%
Maize	62729	51000	11,729.00	19%

Source: Agriculture Marketing Information Service (AMIS) & Self Collected Data

In table 5, both primary and secondary data have been analyzed to determine the cost of producing various crops. The study has identified the production cost of crops, under commercial fertilizers and manure composting plants (bio-fermenter). The above table clearly shows that wheat crop production under manure composting plant (bio-fermenter) has saved 20 percent farmer cost as compared to fertilizers. Similarly, composting has reduced farmer production costs by 18 percent and 19 percent for rice and maize, respectively. Furthermore, the farmers reported by using bio-fermenter plants crop yield has been increased up to 10 percent for each crop.

6.2 Bio-Fermenter Plant of Manure Composting (2-acre)

In this section of the study, data has been collected to evaluate the bio-fermenter plant and its benefits for farmers. The study has calculated the expenses related to bio fermenter plant-like variables cost, maintenance, and fixed cost. All the costs related to the plant have been collected through meetings with experts, farmers, and stakeholders.

As mentioned earlier four types of plants have been considered in our study as 2-acre, 6-acre, 12-acre, and 24-acre plants. The bio-fermenter plants of different sizes with appropriate measurements have given below in table 7. The various plant expenses, such as construction, operational, and other costs, are discussed below in table 8, according to plant size.

The average total cost for a bio-fermenter plant of 2 acres, is considered as Rs.28000/=. The livestock manure for preparation of plant for single time is considered as the variable cost of Rs.1000=/. According to data, the operational cost of labor, maintenance, and manure has taken as Rs.33600/= per year. Microbe's cost is considered an important variable cost for manure composting plants to work properly. The cost of microbes for the lants is assumed to be Rs.700/= per month and Rs.4200=/ per annum as mentioned in table 8.

Because some farmers sell their manure cake in the market, animal manure is also considered as an opportunity cost with Rs.3000=/ per annum for the farmer. As a result, the overall cost of the plant (microbes, input, labor, and maintenance) is projected to be Rs.68800/ per year for the farmer to produce a 2-acre crop every season.

By analyzing the data, estimations have anticipated that through (2 acres) bio-fermented plant farmers can save up to Rs.30100=/ per annum. According to data collected, the average number of manure cakes produced by a half trolley or 250 kg is around 300 units of manure cake. Fertilizer emissions have been assumed using data from published reports and calculated to be 0.59 tons per year, as shown in table 8.

Dung cake has an average weight of 0.68 kg per unit, and 1 kg of dried animal dung emits 22.9 g (0.023 kg) of carbon dioxide (Venkataraman., et al. (2005)). Hence it has been assumed by using bio-fermenter plant farmers may also save the environment of the country. The international market price of 1-ton carbon emissions costs Rs.6200 (40 US$) (World Bank 2018). As a consequence, each 2-acre plant may provide Rs.3696 in environmental benefits in terms of carbon reduction every year. The total benefit economic and environmental from the 2-acre bio-fermenter plant is worth Rs.46840 (table 8). The data

analysis also showed that if the cost of the 2acre plant is subtracted from the total benefits, a net benefit of Rs.6040=/ is generated (total benefits-total cost each year). Furthermore, the study evaluated the investment of cost-benefit analysis and internal rate of return (IRR) as project evaluation techniques.

The present value of costs and benefits has been estimated by using the current market interest rate as 7 percent and mentioned in the appendix of the study. By subtracting costs from benefits net return has been calculated and then converted into present value. Our results have revealed that all size of bio-fermenter plants recovers their costs in the 5^{th} year after installation.

The average life of a bio-fermenter is considered to be 14 years. After the fifth year of installation, the bio-fermenter plant would generate purely net profit (benefit-all costs), i.e., after subtracting all operational costs. According to the benefit-cost ratio, if we invest Rs.1=/ on a (bio-fermenter) plant, the study has assumed it would generate Rs.1.1=/ in return on a (2-acre bio-fermenter) plant. The IRR results of the plant clearly show that investing in a (bio-fermenter) plant creates a greater return than the current market interest rate, indicating the investment's feasibility. The internal rate of return (IRR) for each of the four plants varies; comprehensive information is provided in table 7 and 8.

Due to space constraints, the study has only considered the 5-year life of the plant as mentioned in table 8. Subsequently, in the appendix section at end of the thesis, the cost-benefit analysis of the 2-acre bio-fermenter plant has been reported for 14 years. Similarly, the cost-benefit analysis of (medium size 6 acre), and large size (12 and 24-acre plant) detailed has mentioned in appendix-2B, 2C, and 2D respectively.

Following are the limitations of bio-fermenter plant:

- Households without livestock may have to suffer from additional costs.
- Availability of microbes could be costly for farmers.
- Bio-fermenter plant considered as a laborious job and required to pay labor daily.
- Fertilizer from the bio-fermenter plant must be used within 10 days or the major organic elements will evaporate.

Following are the pros and cons of cost-benefit analysis

- Cost and benefit analysis of bio-fermenter plant could help farmers annual cost of production by minimizing fertilizers.

- Cost benefit analysis of bio-fermenter plant could help policy makers to decide which method of fertilizer is suitable to farmers.
- Cost and benefit analysis of bio-fermenter plant could motivate stakeholders to invest in agriculture.

Table 7: Shows summary of manure composting through bio-fermenter plant.

Size of manure composting bio-fermenter plant	**Fixed cost of plant**	**Internal rate of return, IRR**	**Measurement for construction of the plant**
2-acre plant	Rs. 28000=/	13 percent	Bio-fermenter pants for 2-acre can be constructed following as 7 feet in length, 5 feet wide, and 4 feet deep.
6-acre plant	Rs. 75000=/	18 percent	Bio-fermenter pants for 2-acre can be constructed following as 9 feet in length, five feet wide, and 5 feet deep.
12-acre plant	Rs.145000=/	25 percent	Bio-fermenter pants for 2-acre can be constructed following as 20 feet in length, 10 feet wide, and 4 feet deep.
24-acre plant	Rs. 300000=/	34 percent	Bio-fermenter plants for 2-acre can be constructed following as 24 feet in length, 20 feet wide, and 5 feet deep.

Table 8: Per Annum Cost and Benefit Analysis of 2-acre Plant (Bio-fermenter)

Years	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
The average cost to the owner (per plant)	28000					
Operational cost (labor+ maintenance+ price of manure) per year (Pkr)	33600	33600	33600	33600	33600	33600
The opportunity cost of animal manure	3000	3000	3000	3000	3000	3000
Microbes cost per plant per season (Pkr)	4200	4200	4200	4200	4200	4200
Total cost	68800	40800	40800	40800	40800	40800
Present value of total cost	68800	38131	35636	33305	31126	29090
Present value of total cost with each adding year (Pkr)	68800	106931	142567	175872	206998	236088
Fertilizer saved by shifting to manure composting plant per year (Pkr)	30100	30100	30100	30100	30100	30100
Yield increase benefit of manure composting plant (pkr)	12900	12900	12900	12900	12900	12900
Total economic benefits of manure composting plant	43000	43000	43000	43000	43000	43000
Emission from fertilizer consumption in tons	0.59	0.59	0.59	0.59	0.59	0.59
Value in monetary terms (Pkr)	3696	3696	3696	3696	3696	3696
Value of emission (Pkr)	144	144	144	144	144	144
Total environmental benefits of manure composting plant	3840	3840	3840	3840	3840	3840
Total benefits of each year (economic + environmental)	46840	46840	46840	46840	46840	46840
Present value (total benefits)	46840	43776	40912	38236	35734	33396
Present value with adding each year	46840	90616	131528	169764	205498	238895
Net return	-21960	-16315	-11039	-6108	-1500	2807
BCR	**1.07**					
IRR	**13 %**					

Source: Author's own calculated Excel Results

CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

The proceeding chapter consists of relevant conclusions and recommendations based on the objectives of the study and statistical estimations of survey data. Further, this chapter helps out to understand the deficiencies in government policy. Also, recommend some most relevant strategic policies to relevant authorities and policymakers.

7.1. Conclusion

Manure is a great asset and if well-managed could serve as organic fertilizers. The study has identified poor manure management under inappropriate methods. Manure is often stored without proper storage leaving it susceptible to nutrient loss by rain and sun. Further, this study aimed to explore the farmer's awareness related to organic farming in the region, and also review the government policy and implementations by the relevant agricultural institutions. Also, the research has estimated the manure potential and fertilizer production in the country. The per acre crop production through cost-benefit analysis under bio-fermenter composting plant has also been considered.

The study has considered four types of farm size to estimate, cost-benefit analysis for farmers. These different farm-size composting installations are easily reproducible and also cost-effective. Also, more sustainable in both economic and environmental terms to dispose of manure and turn it into a resource. For this purpose, a thorough analysis of the farmland situation of farmers, overall policy review, and experts' view has been considered.

The dilemma of the agriculture sector in Pakistan is to produce or import inorganic fertilizer in the country. Instead to shift to the natural recycling methods through the presence of astounding organic waste. If "Soil is Healthy Farmer is Wealthy" the slogan must get treatment through the proper giving awareness to our farmer that currently does not know about organic farming. Pakistan cannot achieve success in the agriculture sector with high productivity until taking the agriculture sector as its primary priority. Manure management strategies should be assured using effective policy to inform stakeholders and farmers on the benefits of composting and the use of its final product. Such a condition could help farmers, especially the small ones, to overcome the economic problems that often affect them.

The farmers in Pakistan, are unaware of the existence of a profitable market for compost. The farmers should encourage in producing composting through the bio-fermenter plants and others. According to experts' opinion, it has been observed that farmers must learn to stop saying words like "Roddi" to livestock manure as it considers the "brown gold" for the farmer and "urine" as the urea fertilizer. Finally, concluded in the study that waste material of any kind like green manure, poultry, leaves, and grass can be useful for the soil, and the farmer must use it as natural fertilizer in the form of stabilization.

Cost and benefit analysis of livestock manure through the bio fermenter has proved a cost-effective method in our agriculture sector. Similarly, through bio fermenter plants farmers could produce with low input and with high yield. However, because there is no appropriate management of this animal excrement of manure urine, a massive amount of natural organic resources is wasted every year in our country. The livestock is our only opportunity to reverse our soils and produce sustainably.

7.2. Policy Recommendations

There is a huge potential for livestock manure in the country; however, with time import of fertilizers is increasing every year. Livestock manure is a natural resource and is wasted in huge amounts every year in the country. Usage of livestock manure could save the national spending on fertilizers and save the cost of a farmers by enhancing growth. On the policy side, manure often is considered waste, and government policies are strongly related to this view. Additionally, provincial and federal institutions of agriculture like PARC/NARC, are responsible for formulating policies on organic farming. The following policies on organic farming must enforce including stakeholders and other private agencies.

1. Government should promote composting techniques through relevant agricultural institutions like the university of agriculture, Faisalabad (UAF).
2. Agriculture banks in Pakistan, such as ZTBL, should provide subsidies for the adoption of new simple technology methods related to organic farming.
3. Government should organize sensitization programs to inform policymakers and other actors, adoption of these practices with control and adequate enforcement.
4. Government ministries like (PARC), and (NARC) need to coordinate their policies on manure management in agriculture.
5. Capacity-building programs, vocational training on manure management especially through extension workers and pamphlets, should circulate in rural areas to motivate farmers for organic farming.

6. Research programs are required to test and demonstrate the suitability and benefits of manure management to provide evidence on the benefits of good manure management practices.
7. The implementation of manure composting techniques like bio-fermenter should adopt by farms under government authorities like livestock farms, fish farms, and poultry farms.

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Appendix-A:

Improving the composting of Manure Materials from Farmlands, a step towards Climate Smart Agriculture

Disclaimer:

I am Khizar Nazir, a student of MPhil Environmental Economics at Pakistan Institute of Development Economics. I am working on a thesis titled "Improving the Composting of Manure Materials from Farmlands, a Step towards Climate-Smart Agriculture in Pakistan." The purpose of my project is to know about the knowledge, attitude, practices, and barriers related to manure composting of farmers on farmlands. It also gave us the way to engross the awareness of farmers and other influencing factors related to manure composting. The interview has taken 20 minutes know best of your information. All identity information obtained through this survey will be kept strictly confidential, and your responses would never be revealed to anyone unless there are exceptional legal circumstances, which are extremely unlikely to occur. Furthermore, it is strongly advising you not to make a wild guess. There is always the option of 'do not know,' which is also correct. This has helped me to understand the research gap in Pakistan. We would acknowledge your effort with the institution name in my project.

Instructions:

Please answer the following questions before beginning this survey to determine if you are available to participate in this survey. If you answered 'No' to any of the questions, please let us know; otherwise, you are free to continue with the survey.

Do you agree to participate in this survey?

1. Yes ☐
2. No ☐

← *Tick only one option*

Do you have 20 minutes to complete this survey?

1. Yes ☐
2. No ☐

← *Tick only one option*

Section (A): General information from rural farmers:

Province: _____

District/Tehsil: _____

Village Name: _____

Name: _____

Age: _____

Education (years): _____

Mobile number: _____

Section (B): Manure Knowledge of traditional farmers:

1. Currently how much land you are cultivating including your land, rented or sharecropping? (No. acres) _____
2. Out of this how much land do you own? _____
3. How many animals do you have (only big animals)? _____**If no *(»section B)***
4. During the last 12 months, did you use livestock manure in crop production?
   [1] Yes [2] No
5. If yes, please specify from the following?
   [1] Use on land [2] manure cake [3] sale [4] other if any
6. Please show me how you are managing the stock of manure?
   [1] Open [2] Ditch [3] covered [4] other if any

No. of transfer	Months [1] June [2] September [3] December [4] Other	Source of transfer [1] trolley /tractor [2] Bullock cart [3] hand cart [4] other	Cost of labor Rs/= [1] 0-1000 [2]1000-2000 [3] 2000-3000 [4] other	Cost of transfer (tractor) trolley [1] 0-500 [2]500-1000 [3] 1000-1500 [4] other	Per unit [1]0-5 (trolley) [2]5-10 (trolley) [3]10-15 (trolley) [4] other	After shifting irrigate [1]0-24 hours [2]24-48 hours [3]48-72 hours [4] other
1						
2						

3						
4						

Section (C): Composting awareness of farmers:

1. Are you familiar with or aware of manure composting? [1] Yes [2] No If **no** ***(»Q 3)***

2. If yes, please provide the source from which you learned about manure composting (multi-section)? [1] TV/radio [2] Newspaper [3] Extension worker [4] from another farmer [5] NGOs/GOVT. [6] FAO [7] PARC/NARC [8] Other if any

3. In your area, if any farmer is composting manure e.g., dig a ditch and use it with water? [1] Yes [2] No **If no** ***(»Q 9)***

4. Have you ever visited the manure composting plant in your area? [1] Yes [2] No

5. Is it a successful method if you ever visited the plant? [1] Yes [2] No

6. If yes, report a maximum of three benefits: [1] ----------[2] ----------[3] ----------

7. If not, what are the constraints of the manure composting technique that you are aware of (multi-section)?

[1] No increase in production [2] not cost-effective [3] increase weeds infestation [4] other if any

8. Have you further acquired any information to install a manure composting plant? [1] Yes [2] No

9. If No, why did you not avail of the opportunity to compost manure?

[1] Financial constraint [2] availability of farm structures [3] Not feasible technology [4] other if any

10. If yes, then did you install the manure composting plant? [1] Yes [2] No

11. According to you what is the optimal way to use manure? _____

Section (D), Farmer Cost of major crops production (PKR/= per acre)?

D-1= Wheat, D-2= Rice and D-3= Maize(multi-section)

Wheat ☐ Rice ☐Maize ☐ If no crop is sown in recent years **(»C-5)**

Major Crop	**Wheat**		
Land preparation (total)	**Own/Rent**	**Per unit or hour**	**Cost**
Own tractor/rent	[1] Yes [2] No		
Disk plow	[1] Yes [2] No		
Cultivator	[1] Yes [2] No		
Land leveling	[1] Yes [2] No		
Cost for Cultivation			
Sowing cost though tractor/drill	[1] Yes [2] No		
Seeds for cultivation	[1] Yes [2] No		
The labor cost of sowing wheat by hand	[1] Yes [2] No		
Labor cost to spread fertilizer in the field	[1] Yes [2] No		
Canal water	[1] Yes [2] No		
Cost of tube well water	[1] Yes [2] No		
Other fertilizers			
Major Crop	**Rice**		
Land preparation (total)	**Own/Rent**	**Per unit or hour**	**Cost**
Own tractor/rent	[1] Yes [2] No		
Disk plow	[1] Yes [2] No		
Land leveling	[1] Yes [2] No		
Cultivator	[1] Yes [2] No		
Wet planking	[1] Yes [2] No		
Cost for Cultivation			
Seeds of rice for cultivation	[1] Yes [2] No		
Water cost of tube well for the cultivation of rice	[1] Yes [2] No		
Canal water	[1] Yes [2] No		
The labor cost of sowing rice	[1] Yes [2] No		
Labor cost to spread fertilizer in the field	[1] Yes [2] No		
Other fertilizers			

Crop	**Maize**		
Land preparation (total)	**Own/Rent**	**Per unit or hour**	**Cost**
Own tractor/rent	[1] Yes [2] No		
Rotavator	[1] Yes [2] No		
Land leveling	[1] Yes [2] No		
Seedbed preparation	[1] Yes [2] No		
Cost for Cultivation			
Seeds for cultivation	[1] Yes [2] No		
Cost of tube well water for sowing	[1] Yes [2] No		
canal water	[1] Yes [2] No		
The labor cost of sowing maize seeds	[1] Yes [2] No		
Labor cost to spread fertilizer in the field	[1] Yes [2] No		
fertilizers			

Section (D-4): Farmer Cost of production through focus community discussion (PKR/= per acre)?

Please elaborate on the farmer's cost of production from the following (per acre)?

Farmers' numerous costs	**Per unit**	**Cost**
Rent of Rootavator with tractor		
Rent of lazar planking with the tractor for a single time		
Rent of land in your area (per acre)?		
What is the cost of manure (per acre) or (per trolley)?		
Production of major crops	**Per 40 kg (Mond)**	**Price**
The yield of Wheat in your area		
The yield of Rice in your area		

Maize Yield of maize in your area		

Appendix-2: Variable cost manure composting (per month)

Variable cost	**Quantity/ cost**	**Price / unit**	**Total Cost**
Labor cost			
Maintenance cost			
Manure purchase cost			
Microbe's cost			
Depreciation cost			
Other			
The total variable cost to the farmer			

Appendix-2A Cost-Benefit Analysis of Plant (2-Acre) For 14 Years

2 acre manure composting plant																
Size of the plant	2															
Number of crops	2															
Average total fix cost of 2 acre manure composting plant (pkr)	28000															
price of urea per (40 kg) in rupees (Pkr)	1850															
Quantity of urea used for wheat/rice per acer in Mond (40kg)	2															
price of DAP per acre used 40 kg in terms of price (pkr)	5350															
Quantity of DAP used for wheat/rice per acer in Mond (40kg)	2															
Quantity of zinc sulphate used for wheat/rice per acre 5kg	1															
zinc sulphate price per 5 g bag in rupees (pkr)	650															
benefit of wheat per acre per year per 40 kg	3															
Price of wheat per 40 kg per year Pkr	1800															
benefit of rice per acre per year per 40 kg	3															
price of rice per 40 kg per year pkr	1250															
Average Labour cost per month (7) days	400															
Average Labour cost per plant per season (3 times)	1200															
Average mantainance cost per plant for season	600															
1 year is equal to 12 month	12															
Carbon emission from fertilizer per acre per 40 kg fertalizer in kg)=	22															
The process to convert weight from gram to kg. 1 kg=1000g=	1000															
present market interest rate	7															
One ton contains 907.2 kg	907.2															
average Price of animal dung per piece (Rs.5/pieces) in pkr	5															
average quantity of manure cake that can be made from 2 acre manure	300															
Exchange rate	157.5															
Average quantity of manure used in plant (half trolley)(per kg)	250															
Average price of manure per 2 acre plant in (pkr)	1000															
Price of CO2 emission in international market in pkr (US$40/ton)	6300															
microbes cost per plant (7 days) in (pkr)	700															
microbes cost per month per plant per seaon (pkr)	2100															
Total carbon emission from manure per kg (22.9 g per kg)	0.023															
Years	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Cost of the plant																
average Cost to owner (per plant)	28000															
Operational cost (labor+ mantinance+ price of manure) per year (pkr)	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	33600	
opportunity cost of animal manure	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	
microbes cost per plant per season (pkr)	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	4200	
Total cost	68800	40800	40800	40800	40800	40800	40800	40800	40800	40800	40800	40800	40800	40800	40800	
Present value of total cost	68800	38131	35636	33305	31126	29090	27187	25408	23746	22192	20741	19384	18116	16931	15823	
Present value of total cost with each adding year (pkr)	68800	106931	142567	175872	206998	236088	263275	288683	312429	334621	355362	374746	392862	409792	425615	
Economic benefits of shifting from fertilizer to manure composting plant																
fertilizer saved by shifting to manure composting plant per year (Pkr)	30100	30100	30100	30100	30100	30100	30100	30100	30100	30100	30100	30100	30100	30100	30100	
yield increase benefit of manure ccmpositng plant (pkr)	12900	12900	12900	12900	12900	12900	12900	12900	12900	12900	12900	12900	12900	12900	12900	
Total economic benefits of manure composting plant	43000	43000	43000	43000	43000	43000	43000	43000	43000	43000	43000	43000	43000	43000	43000	
Environmental benefits of manure composting plant																
Emission from fertilzer consumtion in tons	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	
Value in monetary terms (pkr)	3696	3696	3696	3696	3696	3696	3696	3696	3696	3696	3696	3696	3696	3696	3696	
Emission from animal dung (tons)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	
Value of emission (pkr)	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	
Total environmental benefits of manure composting plant	3840	3840	3840	3840	3840	3840	3840	3840	3840	3840	3840	3840	3840	3840	3840	
Total beneifits of each year (economic + environmental)	46840	46840	46840	46840	46840	46840	46840	46840	46840	46840	46840	46840	46840	46840	46840	
present value (total benefits)	46840	43776	40912	38236	35734	33396	31212	29170	27261	25478	23811	22253	20798	19437	18165	
present value with adding each year	46840	90616	131528	169764	205498	238895	270106	299276	326538	352016	375827	398080	418878	438315	456480	
Net return	-21960	-16315	-11039	-6108	-1500	2807	6831	10593	14109	17394	20465	23334	26016	28523	30865	
BCR	1.07															
IRR	13%															

Appendix-2B Cost-Benefit Analysis of Plant (6-Acre)

Years	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Cost of the plant						
Average Cost to the owner (per plant)	75000					
Operational cost (labor+ maintenance+ price of manure) per year (Pkr)	72000	72000	72000	72000	72000	72000
The opportunity cost of animal manure	18000	18000	18000	18000	18000	18000
Microbes cost per plant season (Pkr)	16200	16200	16200	16200	16200	16200
Total cost	181200	106200	106200	106200	106200	106200
Present value of total cost	181200	99252	92759	86691	81019	75719
Present value of total cost with each adding year (Pkr)	181200	280452	373212	459902	540922	616641
Fertilizer saved by shifting to manure composting plant per year (Pkr)	90300	90300	90300	90300	90300	90300
Yield increase benefit of manure composting plant (Pkr)	27900	27900	27900	27900	27900	27900
Total economic benefits of manure composting plant	118200	118200	118200	118200	118200	118200
Emission fertilizer consumption in tons	0.70	0.70	0.70	0.70	0.70	0.70
Value in monetary terms (Pkr)	4435.2	4435.2	4435.2	4435.2	4435.2	4435.2
Emission from animal dung (tons)	0.21	0.21	0.21	0.21	0.21	0.21
Value of emission (Pkr)	1298	1298	1298	1298	1298	1298
Total environmental benefits of manure composting plant	5734	5734	5734	5734	5734	5734
Total benefits of each year (economic + environmental)	123934	123934	123934	123934	123934	123934
Present value (total benefits)	123934	115826	108248	101167	94548	88363
Present value with adding each year	123934	239759	348008	449175	543723	632086
Net return	-57266	-40693	-25204	-10728	2801	15445
BCR	**1.09**					
IRR	**18%**					

Appendix-2C Cost-Benefit Analysis of Plant (12-Acre)

Years	**0**	**1**	**2**	**3**	**4**	**5**
Cost of the plant						
The average cost to the owner (per plant)	145000					
Operational cost (labor+ maintenance+ price of manure) per year (Pkr)	144000	144000	144000	144000	144000	144000
The opportunity cost of animal manure	35000	35000	35000	35000	35000	35000
microbes cost per plant per season (Pkr)	27000	27000	27000	27000	27000	27000
Total cost	351000	206000	20600	206000	206000	206000
Present value of total cost	351000	192523	17992	168157	157156	146875
Present value of total cost with each adding year (Pkr)	351000	543523	723452	891609	1048766	1195641
Fertilizer saved by shifting to manure composting plant per year (Pkr)	180600	180600	180600	180600	180600	180600
Yield increase benefit of manure composting plant (Pkr)	50400	50400	50400	50400	50400	50400
Total economic benefits of manure composting plant	231000	231000	231000	231000	231000	231000
Emission from fertilizer consumption in tons	1.41	1.41	1.41	1.41	1.41	1.41
Value in monetary terms (Pkr)	8870.4	8870.4	8870.4	8870.4	8870.4	8870.4
Emission from animal dung (tons)	0.82	0.82	0.82	0.82	0.82	0.82
Value of emission (Pkr)	5194	5194	5194	5194	5194	5194
Total environmental benefits of manure composting plant	14064	14064	14064	14064	14064	14064
Total benefits of each year (economic + environmental)	245064	245064	245064	245064	245064	245064
present value (total benefits)	245064	229032	214048	200045	186958	174727
Present value with adding each year	245064	474096	688145	888190	1075148	1249875
Net return	-105936	-69427	-35307	-3419	26383	54235
BCR	**1.11**					
IRR	**25%**					

Appendix-2d Cost-Benefit Analysis of Plant (24-Acre)

Years	**0**	**1**	**2**	**3**	**4**	**5**
Cost of the plant						
The average cost to the owner (per plant)	300000					
Operational cost (labor+ maintenance+ price of manure) per year (Pkr)	276000	276000	276000	276000	276000	276000
opportunity cost of animal manure	65000	65000	65000	65000	65000	65000
microbes cost per plant per season (Pkr)	54000	54000	54000	54000	54000	54000
Total cost	695000	395000	395000	395000	395000	395000
Present value of total cost	695000	369159	345008	322438	301344	281630
Present value of total cost with each adding year (Pkr)	695000	1064159	1409167	1731605	2032948	2314578
fertilizer saved by shifting to manure composting plant per year (Pkr)	361200	361200	361200	361200	361200	361200
yield increase benefit of manure composting plant (Pkr)	95400	95400	95400	95400	95400	95400
Total economic benefits of manure composting plant	456600	456600	456600	456600	456600	456600
Emission from fertilizer consumption in tons	2.11	2.11	2.11	2.11	2.11	2.11
Value in monetary terms (Pkr)	13305.6	13305.6	13305.6	13305.6	13305.6	13305.6
Emission from animal dung (tons)	2.97	2.97	2.97	2.97	2.97	2.97
Value of emission (Pkr)	18697	18697	18697	18697	18697	18697
Total environmental benefits of manure composting plant	32003	32003	32003	32003	32003	32003
Total benefits of each year (economic + environmental)	488603	488603	488603	488603	488603	488603
present value (total benefits)	488603	456638	426765	398846	372753	348367
present value with adding each year	488603	945241	1372006	1770852	2143605	2491972
Net return	-206397	-118918	-37161	39247	110656	177394
BCR	**1.15**					
IRR	**34%**					