STUDY ON TREE-CROP-LIVESTOCK INTERACTION WITH ENVIRONMENT IN THE RURAL AREAS OF SIRAJGANJ

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STUDY ON TREE-CROP-LIVESTOCK INTERACTION WITH ENVIRONMENT IN THE RURAL AREAS OF SIRAJGANJ

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CERTIFICATE

This is to certify that the thesis entitled, **"STUDY ON TREE-CROP-LIVESTOCK INTERACTION WITH ENVIRONMENT IN THE RURAL AREAS OF SIRAJGONJ"** submitted to the DEPARTMENT OF AGROFORESTRY AND ENVIRONMENTAL SCIENCE, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGROFORESTRY AND ENVIRONMENTAL SCIENCE**, embodies the results of a piece bona fide research work carried out by **MOST. ISMAT SADIA AHMED**, Registration No. 11-04393 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated: June, 2018
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Dr. Nazmun Naher
Professor

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ABSTRACT

Agroforestry is a land use management system in which trees or shrubs are grown around or among crops or pastureland. This intentional combination of agriculture and forestry has varied benefits, including increased biodiversity and reduced erosion. Livestock-based Agroforestry or mixed farming systems provide important opportunities for increasing food production from farm animals. The objectives of the study were characterization of livestock-based agroforestry systems in the rural area of Sirajganj district and to know the interaction among tree, crop, livestock with environment in the study area. The study was conducted in ten villages of two Upazilas of Sirajganj district in February to December 2017. A well-structured questionnaire was developed based on objectives for collecting information by purposive random sampling method of 50 respondents. Maximum people of the villages were farmers and agricultural production was their main occupation. There were different agroforestry systems found in the study area namely- Agri-silviculture (15), Silvopasture (10) and Agro-silvopasture (25) where different types of agroforestry practices were observed like mango based agroforestry (12), jackfruit based agroforestry (28) etc. The farmers practiced tree plantation and livestock rearing. To conserve the soil of land and to protect the soil from washed away, for getting different usable products farmers planted different tree species. Among fruit trees 84% farmers had mango tree, and among timber tree 96% respondents had Eucalyptus. There were different interaction among tree-crop-livestock and environment. By Pearson Product Moment Correlation Coefficient it was observed that, there was a statistically significant relationship among tree-crop-livestock and environment and farm size that was 0.747, road side plantation that was 0.934 and production of the farmers that was 0.674 respectively. This study would therefore make use of the local knowledge of farmers to understand the tree-crop-livestock interactions on small holder farms and advice on which agroforestry practices best for sustainable agro-ecological intensification.

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CHAPTER I

INTRODUCTION

Background

Economic production and consumption opportunities rely on environmental resources in recent years. The loss or degradation of environmental resources such as forest has led to global concern. About half of the world's tropical forests have been cleared, according to the FAO. Forests currently cover about 30 percent of the world's landmass, according to National Geographic (2016). The Earth loses 18.7 million acres of forests per year, which is equal to 27 soccer fields every minute, according to the World Wildlife Fund (WWF, 2016). It is estimated that 15 percent of all greenhouse gas emissions come from deforestation, according to the WWF. In 2016, global tree cover loss reached a record of 73.4 million acres (29.7 million hectares), according to the University of Maryland. The tropics alone record an annual forest loss estimated at 15.2 million hectares. Agriculture has been estimated to cause about 80% of deforestation around the world (Kissinger and Herold, 2012) and this has caused degradation of agricultural lands. The fast growing population exerts pressure on the limited land resources leading to a marked decreased in landholdings worsened by the weak existing institutions (Doulton *et al*., 2015). The high rate of deforestation has also been exacerbated by ill adapted and extensive agricultural practices that resulted in severe soil erosion and fertility and severe impact on water resources.

When the soil fertility losses, it led to a decline in agricultural productivity which further pushes farmers to clear new portion of the forest for cultivation (FAO, 2010

and Doulton *et al.*, 2015). Small landholdings and competition for land from other human activities makes expansion of agriculture into novel lands a very costly solution to increasing agricultural productivity in the case where biodiversity protection and the ecosystem goods have been accorded more attention (MEA, 2005). In order to reverse the trends, effective policies, competent institutions, legal and regulatory frameworks, monitoring mechanisms and knowledge should be needed. Good practices that can lead to sustainable land management capable of generating global environmental benefits while at the same time supporting local, economic and social development must be promoted (Dimobe *et al*., 2015).

Agroforestry has been increasingly considered as a practice that can in a sustainable way intensify agriculture to enhance food security by applying socially and cost effective management methods whilst conserving natural resources. But never the less, land sparing for tree establishment might be problematic in the case of small land holdings and insecure land tenure (Mbow *et al*., 2014). The sustainable agricultural intensification concept is defined "as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services" (Godfray *et al*., 2010).

Justification of the study

Livestock-based Agroforestry or mixed farming systems present important opportunities for increasing food production from farm animals. Trees are grown to provide longer term economic returns to the farm, while livestock generate annual income. However, tree crops and products can also improve the short term economic output of the farm system. Along with direct production benefits, tree, crop and

livestock can also improve resource use and conservation outcomes through greater light and nutrient capture, reduce erosion, wildlife food 1.54% and habitat, and risk reduction. In Bangladesh, contribution of livestock in GDP with growth rate was 3.32% (BBS, 2017). About 20% of the populations of Bangladesh earn their livelihood through works associated with raising cattle and poultry (Banglapaedia, 2015). According to the statistics of Directorate of Livestock Services (DLS), production of meat was 71.54 lakh metric tons (BBS, 2017). It is known that,mixed farming systems provide farmers with an opportunity to diversify risk from single crop production, to use labor more efficiently, to have a source of cash for purchasing farm inputs and to add value to crop or crop by-products. Straw and crop residues are the principle feed ingredients in the traditional feeding system of Bangladesh. Nutrient cycling in small scale farming system and feeding system are depending on crop residue availability (Mueller *et al*., 2001). The supplementation in crop residue accounted for about 70% of the total feed intake during the dry season where the livestock provide about 20% of the household income (Sanni *et al*., 2004). It was showed by Saadullah (1995) that maximum agricultural and livestock productivity is from available resources through integrated technology, which employs crops, animals and plants and Huq *et al.* (1997) added the environmental factors with the integration of tree, crop and livestock. In Bangladesh the main income source of farmers are crop and livestock production and another very important source is business. Interaction of Livestock with environment within the confine of production system, but integrating trees in the farming systems can improve crop yields, reduce use of external inputs, diversify farm outputs and sources of income while at the same time enhancing adaptation and mitigating climate change (Garrity *et al*., 2010). Because tropical farmers are aware of the multiple functions of trees, they have been

planting and protecting, selecting and domesticating trees for thousands of years (Schroth and Sinclair, 2003). Industrial livestock production systems cause more harm to environment, while mixed crop-livestock systems are benign to environment. But still there is some lacking, so to know about the overall condition of the farmers the study was conducted.

Objectives:

In mixed farming, cropping, livestock, poultry, fisheries, and possibly other enterprises are present within the farming system. In Bangladesh, different production systems are practiced. Most of the large farms may have more than one enterprise that may be complementary or supplementary depending upon the situation. Bangladesh being an agricultural country, where vast majority of people depend directly upon their own farm production for survival, the country's agriculture is complex, labor intensive and has a low technological and resource base. Financing through livestock was more attractive than taking a loan with a co-operative or any other source. When tree is also added to the integration system, there are also some more benefits- fruits used as human food, some tree leaves used as animal fodder, provides construction materials, sale of tree as fuel wood or whole tree, maintain environmental balance and so on. Considering this, two objectives were found. The objectives of this study was-

1. To know the Characteristics of livestock-based agroforestry systems in the rural area of Sirajganj district.
2. To know the interaction among tree, crop, livestock with environment in the study area with existing problems and their probable solution of the farmer.

CHAPTER II

REVIEW OF LITERATURE

2.1. Mixed farming systems

Mixed farming is a type of farming which involves both the growing of crops as well as the raising of livestock. This type of farming is mostly practiced in continents like Asia and countries like India, Malaysia, Indonesia, Afghanistan, China and Russia. It was first mainly used for self-consumption, but now in countries like US, Japan, etc., this is done for a commercial purpose (Myrdal *et al*., 2011). By definition, such a closed system offers positive incentives to compensate for environmental effects ("internalize the environmental costs"), making them less damaging or more beneficial to natural resource base. Because of the completely different approaches needed to address the environmental effects of mixed farming, this study distinguishes between mixed farming in the developing and in the industrial world. The main challenge is to identify those policies and technologies which allow these systems to grow while sustaining their environmental equilibrium.

2.2. Tree-crop interaction

Basavaraju and Rao (2000) showed that, two types of interaction found in agroforestry system results in positive and negative interactions between trees and crops. Micro-climate amelioration and maintenance or improvement in soil productivity is the major positive interaction while competition for light, water and nutrients, and allelopathy are the major negative interactions in agroforestry systems.

The balance between negative and positive interactions determines the overall effect of interactions in a given agroforestry system. Selection of suitable tree species for agroforestry is important, however many a times it is not possible to select tree species having all the desirable characters for agroforestry because of different production or protection goals. In such situations agroforestry systems have to be managed through planting optimum density of trees, proper spatial arrangement and pruning and thinning of tree crowns and roots to reduce the negative effects of trees.

2.3. Effects of Tree-crop interaction

Tree-crop interaction has both positive and negative effects (Nair, 1993)

2.3.1. Negative interaction (Interference)

a. Shading by the trees, reducing light intensity at the crop level.

b. Root competition between tree and crop for water and/or nutrients in the topsoil. Hereby the tree root architecture is important. Shallow tree root systems are likely to compete more with the crop for scarce nutrients, while deep tree roots can act as a 'nutrient pump' or 'safety net' , where nutrients are so deep that they are out of reach for the crop roots.

c. Trees and crops can be a host of each other’s pests and diseases.

2.3.2. Positive interaction (Facilitation)

a. Nutrient recycling can be based on:

- Nutrients taken up in the topsoil by tree roots in competition with crops,
- Nutrients taken up while leaching down to a deeper layer with tree roots acting as a 'safety net'.

• Nutrients taken up from weathered minerals in deeper layer, with deep tree roots acting as ‘nutrient pump'.

b. Litter production: If litter is high quality (low C/N ratio, low lignin and polyphenolic content), it will decompose rapidly and make nutrients available to the crop and the trees.

c. Mulch: Litter of low quality (high C/N ratio, high lignin and polyphenolic content) mulches decomposes slowly and is suitable as mulch. Mulch maintains soil moisture during the dry season. Especially on sandy soils, where water supply for the crops could be a problem, mulch is important.

d. Nitrogen supply by tree roots to crop roots, either due to root decay or root death following tree pruning or by direct transfer if nodulated roots are in close contact with crop roots,

e. Tree and crop effects reducing weeds (by shading in relevant parts of the year) and reducing dry-season fire risks.

f. Tree and crop effects reducing pest and disease pressure by facilitating biological control agents.

g. Tree effects on microclimate (reducing wind speed, increasing air humidity, providing partial shade)

h. Long term effects on reducing erosion, maintaining soil organic matter content and soil structure.

2.4. Crop-Environment Interaction

The interaction between crop and environment may be positive or negative. When crop residue mixed with soil, it increases soil fertility. Fertile soil required less

amount of inorganic fertilizer. Runoff, erosion and soil degradation are negative impacts of agricultural expansion and intensification. Land runoff from agriculture, together with atmospheric deposition, accounts for about 90% of the phosphorous and 94% of the nitrogen input in Lake Victoria, Africa's largest lake by area (Odada *et al*., 2004).Erosion and lost vegetative cover have caused the depletion of nutrients and organic matter in African soils and have contributed to stagnation in the growth of maize yields.Increased production has caused increased environmental degradation as a result of poor practices used by farmers. Their use of monocropping and lack of fallow cropping have resulted in soils leached of nutrients. Increases in the harvested land area for agriculture have caused cropland conversion from grasslands and forests. This has led to increased levels of erosion, that itself leads to further nutrient leaching when heavy rains come. Increased irrigation has led to falling water tables (Killebrew and Wolff, 2010). These impacts have contributed to the fluctuating or stagnant yields.

2.5. Tree-Crop-Environmental Interaction in Changing Climate

Eike *et al*. (2000) observed that, there is no reason to expect that agroforestry systems will be spared as climate change is projected to affect agricultural and natural ecosystems around the world. Like all other plants and animals, those existing within agroforestry systems will be exposed to temperatures that are higher than those of the past, to higher carbon dioxide concentrations and they may also experience changes in precipitation. These changes will probably affect all system components, and they may even modulate interactions between components. Agroforestry systems are more complex than monoculture situations. They consist of annual and perennial plants, which are often integrated with livestock. Temperature, humidity and ambient CO_2 concentration affect all organ- isms involved in an agroforestry system, possibly in

very different ways, and climate change is projected to alter all of these factors. In light of the high potential of agroforestry for food security, climate change adaptation and mitigation, tree-based agricultural systems are currently being promoted in many parts of the world and they have successfully been established in many regions. Many of the trees that are introduced are long-lived species that are expected to grow on farmers' fields for several decades. These long planning horizons make consideration of climate change impacts on trees particularly important. After all, many trees planted today may still be in place by the middle or even end of the 21st century.

2.6. Tree-Crop-Livestock Interaction for Sustainability

Jabbar and Cobbina (1990) said that, interaction between tree-crop-livestock may be complementary or competitive. Complementarity occurs when one sector provides production inputs to the other. Examples are the use of manure and draft power for crop production, and the use of crop residues, weeds from crop fields and crop processing by-products as animal feeds. Production of grass or grain or tree legumes as relay crops or in association with regular crops may also give rise to complementarity by enhancing both crop and livestock yields. Investment of income from one to the other sector may also create complementarity. Sometimes tree, crop and livestock may compete for land and labor resources. In the short run, conflict may occur over, for example, high quality grazing and dry season vegetable production in lowland valleys, or irrigation may remove land from pasture. In the long run, population growth causes tree or crops to replace pasture, reducing grazing quantity and perhaps quality. Competition for labor occurs with intensification of farming. Manuring, fodder production and animal husbandry require more labor inputs than pastoral herding. If wages rise, because of intensification of farming or of urban demand, then competition for labor is exacerbated. Tree and crop residues may be

used as animal feed or as mulch for soil. Depending on their productivity, these two uses may compete in some circumstances.The agroforestry counterpart of the law of limiting factors states: the more a resource becomes available in the tree-crop environment, the smaller its share becomes in the overall tree-environment-crop interaction. The agroforestry counterpart of the law of the optimum states: the more other limiting resources become available in the tree-crop environment, the greater the share of a resource becomes in the overall tree-environment-crop interaction (Ramun, 2000).

Contribution of tree-crop-livestock interaction to sustainable crop production may be expressed in the following ways (IITA, 1990).

a) A given amount of land can support more people under a tree-crop-livestock system than under either tree or crop or livestock system, because of higher aggregate output under tree-crop-livestock system. Thus tree-crop-livestock system may provide more adequate and nutritionally appropriate diet for a larger population. The importance of higher aggregate production through interaction increases with population growth and as arable crop farming push livestock to marginal lands and reduce marginal productivity of both crop and livestock. The compression of slash and burn systems into shorter fallow cycles, deforestation and overgrazing have led to soil erosion and destruction of natural habitat. Under such a situation tree-crop-livestock interaction has much to contribute to stable increase in both food crop, tree and livestock production.

b) Though, high tech agriculture based on agrochemicals practiced in the developed countries has become a major source of environmental pollution, a significant risk for human and animal health and wildlife. Major environmental threats emanating from

agriculture are soil erosion, leaching and associated effects on water quality. In spite of its high productivity, high tech agriculture may not be the most efficient, cost-effective way of producing food. As tropical Africa gradually moves away from subsistence to commercial agriculture, the pitfalls of high tech agriculture may be avoided or minimized by encouraging tree-crop-livestock interaction in the early stage. Too much dependence on agrochemical components of high tech agriculture at the present stage of African agriculture may make it more unstable and risky and because of the inequitable access to resources, the benefits of high tech is also likely to be inequitably distributed.

c) Interaction of tree-crop-livestock may allow diversification of production, consumption and investment, and contribute to stability of the system by minimizing risk, employing and distributing benefits to more people.

d) Agroforestry is a dynamic, ecologically based natural resource management system that, through which the integration of trees/woody perennials in farm and rangelands, diversifies and sustains production for increased social, economic and environmental benefits.

2.7. Agroforestry Services

Agroforestry has real potential to simultaneously tackle food insecurity and climate change (Kumar and Nair, 2004). There is rich evidence indicating that through its productive and environmental services' functions, agroforestry can provide multiple benefits, helping to arrest land degradation, rural poverty and food insecurity, as well as mitigate other environmental issues such as climate change. Further, agroforestry can provide a wide range of products that diversify farmoutputs, giving a broader economic base and greater food security for farmers (Zomer *et al*., 2016). Other

studies suggest that agroforestry can be more profitable than agriculture or forestry (Fanish and Priya, 2013). It also has high 'land equivalent ratio', indicating efficient use of space (Khasanah *et al*., 2015). Global evidence indicates the importance of agroforestry in local livelihoods and rural landscapes. According to Zomer *et al*. (2010) 43% of the world's agricultural land hadat least 10% tree cover, suggesting that farmers plant trees on their land; in fact, agroforestryis practiced by more than 1.2 billion people worldwide (Jamnadass *et al*., 2013). Investments in agroforestry could, thus, play a strategic role in helping countries meet their key national development goals related to poverty eradication, food security and environmental sustainability (FAO, 2013). Agroforestry benefits from productive and environmental services' functions (Catacutan *et al*., 2017)

2.7.1. Productive functions:

- Diverse products e.g. fruits, nuts,edible leaves, fuelwood, fodder,fiber, timber, gum, resin, medicines
- Increased crop yield
- Enhanced productivity of land
- Increased income
- Clean water

2.7.2. Environmental services functions:

- Micro-and meso-climatic buffering (reduced variability)
- Ground/soil vegetative cover, maintenance of soil organic matter and soilphysical properties
- Increased rainwater infiltration, control of surface run-off and soil erosion,increased flow persistence and reduced flooding risk

- Improved soil fertility through nitrogen fixation and nutrient cycling
- Rehabilitation of degraded land and reduced risk of land depletion
- Contribution to biodiversity and sustainable forest management
- Carbon sequestration and storage

2.8. Relation among Components and Natural Resource Management

From Miller and Spoolman (2011), we know that, a source or supply from which a benefit is produced is called resource. Resources can be broadly classified on the basis upon their availability they are renewable or non-renewable. Natural resources are derived from environment. Many natural resources are essential for human survival, while others are used for satisfying human desire. Conservation is the management of natural resources with the goal of sustainability. Natural resources can be classified as- abiotic resources comprise non-living things (e.g. - land, water, air and minerals such as gold, iron, copper etc., and biotic resources that obtained from biosphere that is forests and their products animals, birds and their products, fish and other marine organisms. Non-renewable resources are formed over very long geological periods. Minerals and fossils are included in this category. Since their formation rate is extremely slow, they cannot be replenished once they are depleted. Renewable resources, such as forests and fisheries, can be replenished or reproduced relatively quickly. The highest the rate at which a resource can be used sustainably it is sustainable yield. Some resources, like sunlight, air and wind are called perpetual resources because they are available continuously, though at a limited rate. Many resources can be depleted by human use, but may also be replenished, thus maintaining a flow. Some of these, like agricultural crops, take a short time for renewal, others, like water take a comparatively longer time, while still others, like forests, take even longer. Dependent upon the speed and quantity of consumption,

overconsumption can lead to depletion or total and everlasting destruction of resources. Important examples are agricultural areas, fish and other animals, livestock, forests, healthy water and soil, cultivated and natural landscapes.

2.9. Benefits of Homestead Agroforestry for sustainable livelihood

Homestead agroforestry is common in most tropical countries and they play a vital role in supporting households in many diverse ways, including provision of food, fuel wood, building materials, and fodder for livestock, and income. It is regarded as source of income diversification and also play crucial cultural and social role in rural communities (Bonifasi, 2004 and Guuroh *et al*., 2011), defined homegardens as land use practices involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably, livestock, within the compounds of individual houses, the whole crop-tree-animal unit being managed by the family labor. Homestead agroforestry is primarily used for subsistence purposes by households; they are increasingly being used to generate income (Mendez *et al*., 2001). The quantity of homestead agroforestry production that actually gets sold is highly variable, differing from one household to another. Homegardens are often overlooked as an important source of food security and income generation in the world. For subsistence and poor farmers, crop varieties and cultivars adapted to particular micro-niches around homesteads are crucial and accessible resources available to provide a secure livelihood. Forestry and trees make a significant source of food security and household income. Forest foods are particularly important in predominantly subsistence economies in remote areas and they have a high potential of supplying food if well managed (FAO, 1996). Wide variety of forest products including non-timber forest products from diverse tree species for fruits, fodder, foods and firewood provide food security to a large low-

income population particularly during periods of drought and works as an insurance against famine and crop failure. Homegardens can contribute to household income in several ways. Income from homegardens comes from selling cereal crops, fruits, vegetables and other cash crops. In many cases, sales of products produced in homegardens significantly improve the family's financial status. Homestead agroforestry plays a vital role in contributing to peoples livelihoods. Maroyi (2009) and Guuroh *et al*. (2011) reported that homestead agroforestry improves the family's nutritional status, health, and food security. Homestead agroforestry therefore, is part of a household livelihood strategy and has gained prominence as a natural asset through which sustainable use of resources, particularly for the livelihoods of the poor, may be achieved.

2.10. Purpose of rearing and feeding practices of livestock

Livestock revolution for the developing countries predicted by the International Food Policy Research Institute in the late nineties is looming in the country through an average 26.0% growth of poultry meat and 29.1% of the egg of commercial chicken racing over some biological hurdles in the last decade. But, dairy or red meat production in the country, even after having an example of waving a magic wand in becoming recent global leader of milk production and meat export by India, is relaxing with an average growth of less than 2.0% (BBS 2011). It is important for various factors, such as- for the growing meat demand, for the ever growing demand for milk and its products. One of the major importance is for its rich manure obtained from the cattle excreta which is almost the omnipotent influence in organic farming. Other reasons are for its: hides, wool, ecosystem (recycling of farm wastes) etc. In this system, the cows are largely confined to sheds where they are fed and milked. Different types of feeds are brought in, including weeds, crop residues, roadside

herbage, fodder from thinning and pruning of crops and purchased concentrates. The nutritional value and importance of the various types of feeds differ seasonally. Weeds and roadside herbage are important in the rainy season, while crop residues and planted forages are the major feeds in the dry seasons.

Potter (1987); Lwoga and Urio (1987); Munthali and Dzowela (1987) said that, in the dairy sector, intensive production refers to systems that are based on zero-grazing and semi-zero-grazing. In semi-zero-grazing, cows are fed on natural and/or improved pastures by day and paddocked by night. They are given a variety of feeds, including forage crops, crop residues and concentrates. The typical small-scale farmer, however, practices zero-grazing or stall-feeding, which is the most intensive form of animal production. In Kenya and to a large extent in Tanzania and Malawi zero-grazing and semi-zero-grazing are associated with animals of high genetic potential such as Friesians, Ayrshires, Guernseys, Jerseys and/or their crosses with local zebus.Though, reports from these countries indicate that feed supply is still a major constraint (there is also a shortage of protein-rich feeds, such as cottonseed cake). There are some techniques of farming system with purpose-

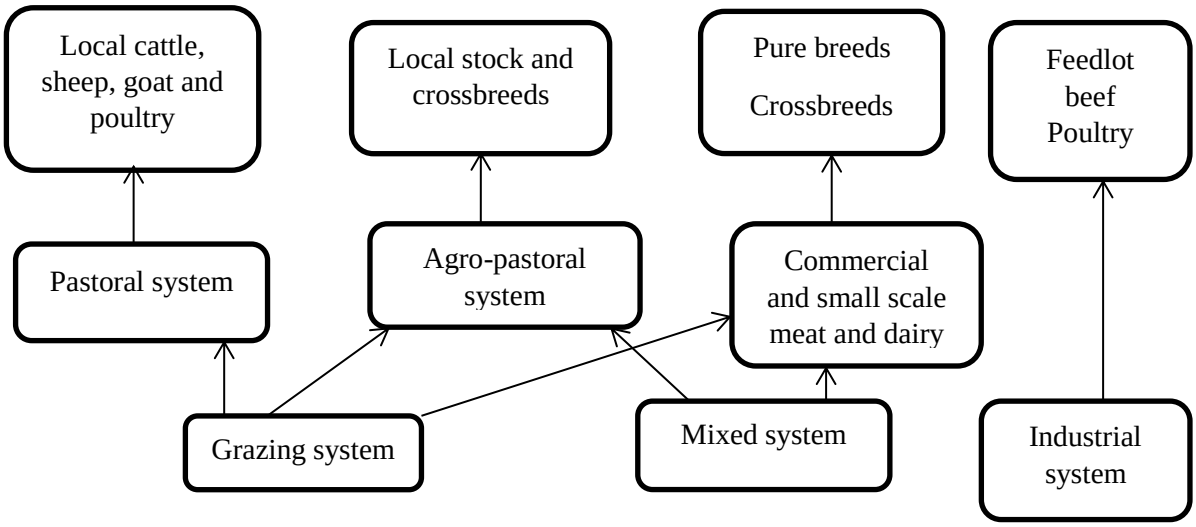

Figure 1. Livestock production technique and production purpose (Peeler and Omore, 1997).

2.11. Livestock-environment interaction

In Production Systems Management Livestock-Environment Interactions(2000), FAO reported that, the ecological footprint of livestock production can be shrunk substantially. The technologies exist but their successful adoption is often constrained by the difficulty in creating the right political and economic conditions in which environmentally friendly livestock production can take place. There are sufficient mechanisms to keep adverse effects of livestock production within tolerable limits and to enhance the net contribution to human welfare. Some livestock-associated environmental problems are-

Degradation of land in semi-arid lands in Africa and Asia, caused by a complex set of factors involving man and his stock, crop encroachment in marginal areas and fuel wood collection. Land tenure, settlement and incentive policies have undermined traditional land use practices and contributed to degradation through overgrazing.

Many highland areas of the tropics, high human population densities are traditionally sustained by complex mixed farming systems. Continuing human population pressures lead to decreasing farm sizes. Livestock, often large ruminants, can no longer be maintained on the farm. The nutrient and farm power balance runs into a widening deficit and disinvestment occurs as natural resources degrade.

In developing countries, slaughterhouses release large amounts of waste into the environment, polluting land and surface waters as well as posing a serious human health risk. Because of weak infrastructure, slaughterhouses often operate in urban settings where the discharge of blood, offal and other waste products is uncontrolled.

Livestock interact with the environment within the confines of a production system. Livestock and livestock waste emit large quantities of greenhouse gases such as

methane and nitrous oxide, contributing to global warming. They can also damage land and vegetation but livestock can also have beneficial effects on the environment. Livestock interact with land (which includes soil and vegetation), water, air, and plant and animal biodiversity. Well-managed grazing livestock can improve species wealth and the integration of livestock into mixed farming systems can improve water infiltration and recharge of groundwater reserves. The biggest contribution of livestock to the environment, however, is in providing for sustained intensification of mixed farming systems. Without this environmental function, the intensification of agriculture could not have taken place and current populations could not be sustained.

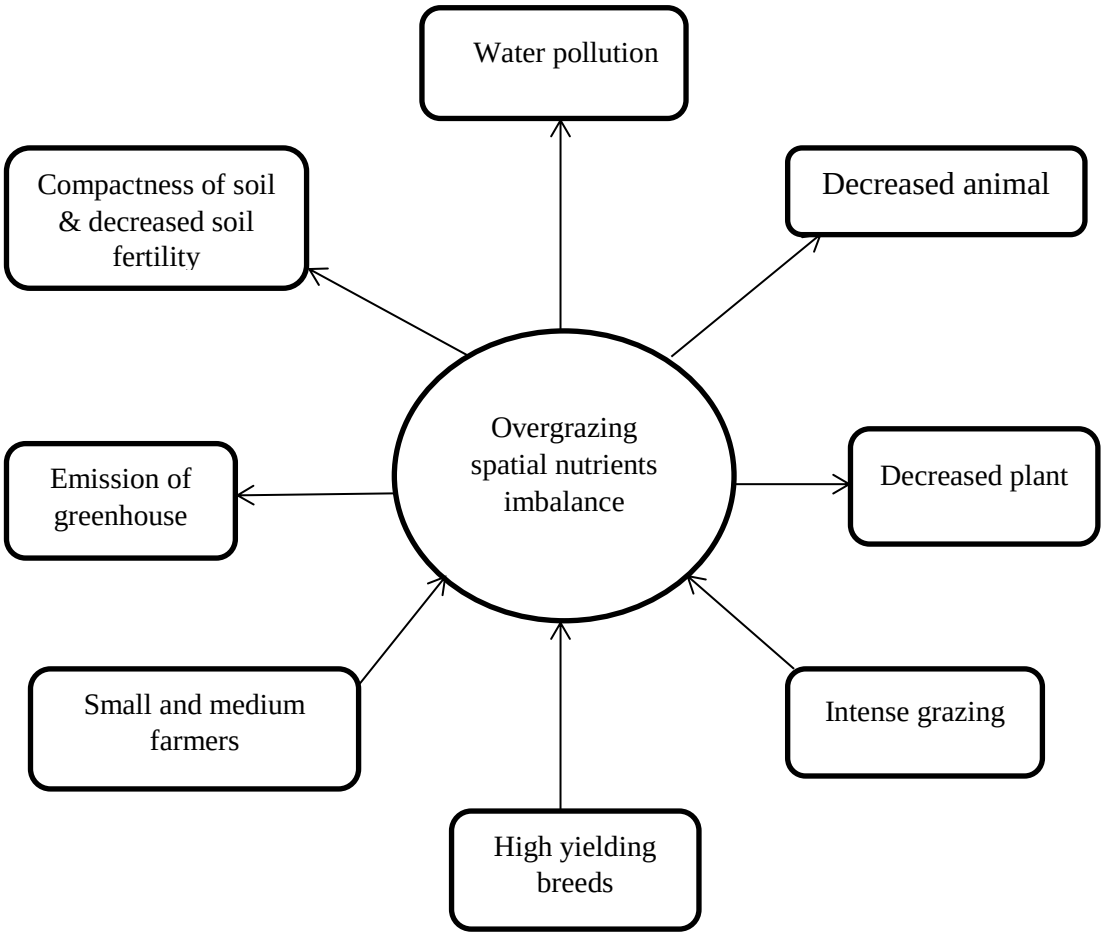

Figure 2. Livestock-environment interaction in mixed farming system (Haan*et al.*, 1997).

2.12. The role of livestock in this changing world

According to Sere and Steinfeld (1996), rearing livestock and milk and meat production will be a key factor in the future health of the planet. Animal agriculture is one of the most important components of global agriculture and livestock is one of the main users of the natural resource base:

• Livestock use 3.4 billion hectares of grazing land and the production from about one-quarter of the world's croplands. In total, livestock make use of more than two-thirds of the world's surface under agriculture, and one-third of the total global land area;

• Livestock raising is the sole source of livelihood for at least 20 million pastoral families, and an important, often the main, source of income for at least 200 million smallholder farmer families in Asia, Africa and Latin America;

• Livestock provide the power to cultivate at least 320 million hectares of land (FAO, 1994), or one-quarter of the total global cropped area. This otherwise would have to be cultivated by hand tools resulting in harsh drudgery, especially for women, or by tractor power with an inevitable drain on foreign exchange. Livestock provide the plant nutrients for large areas of cropland. For example, estimates carried out under this study showed that, for the tropical irrigated areas, manure provides nutrients of an estimated value of US$ 800 million per year.

2.13. Sustainable agro-ecological intensification

Stenchly *et al*. (2011) said that, the importance of ecological processes in agricultural sustainability has long been identified. Though, the role of ecological processes for future global agriculture is positive, it has not been applied at a level capable of positively impacting global land degradation. Agricultural crop yields and available productive lands are being affected by land degradation and deforestation in the

tropics (Leakey, 2014). In addition to this, poverty has made famers unable to buy inorganic fertilizers and pesticides making agro-ecosystem restoration the only means of rehabilitating degraded lands. In Africa research has shown that land degradation is the root cause of yields gaps. Traditional farming systems that restores yield limiting soil depletion opportunities are needed to close the existing yield gaps (Sileshi *et al*., 2008). Studies from Chappel and La Valle (2011) concluded that biodiversity and food security can be achieved using suitable practices that maintain functioning agro-ecosystems.Production systems of cash crop and subsistence food in most part of Africa are being degraded by the increasing demand for food and climate change (Carson *et al*., 2014). Increasing population growth and consumption of more intensive diets of calories and meat have been projected to double by 2050 (Mueller *et al*., 2012). The importance of agroforestry in multi-functional agriculture has been saluted by many researchers. The result of a 94 peer-reviewed articles from western, southern and eastern Africa shows that global maize yields are positively significant with leguminous trees than unfertilized maize and natural vegetation fallows (Sileshi *et al*., 2008).

CHAPTER III

MATERIALS AND METHOD

Materials and methods have an important role in a scientific research. A researcher should be very careful for formulating methods and procedures in conducting the research for the fulfillment of the objectives. Research methodology is a structured set of guideline or activities to generate valid and reliable research results. This chapter describes the research methodology and procedures used to collect and analysis the data and attaining the purposes of the research.

3.1. Locale of the study

Sirajganj District (Rajshahi division) area 2497.92 sq km, located in between 24°01' and 24°47' north latitudes and in between 89°15' and 89°59' east longitudes. It is bounded by Bogra district on the north, Pabna and Manikganj districts on the south, Tangail and Jamalpur districts on the east, Pabna, Natore and Bogura districts on the west. Administration Sirajganj Sub-division was established in 1885 under Pabna district and it was turned into a district in 1984. There are nine Upazilasot Sirajganj District namely- Sirajganj Sadar, Shahjadpur, Raiganj, Belkuchi, Tarash, Chauhali, Kamar Khanda, Kazipur and Ullahpara. Of the nine Upazilas of the district Ullahpara is the largest (414.43 sq km) and Kamar Khanda' is the smallest (91.61 sq km). Mainly considering farm families engaged in mixed farming the study was conducted in two Upazilas named Sirajganj Sadar and Kazipur which were considered as the study area. The site was purposely selected as locale of the study. Five villages (Pipul Baria, Bagbati, Shyampur, Chilgacha and Char-Brahmagacha) of Sirajganj Sadar and

five villages (Gandhail, Patta Gram, Singra Bari, Tengla Hata, and Dublai) of Kazipur Upazilla were randomly selected for conducting this research.

The map of Sirajganj District has been presented and showing the study area Sirajganj Sadar and Kazipur Upazilas.

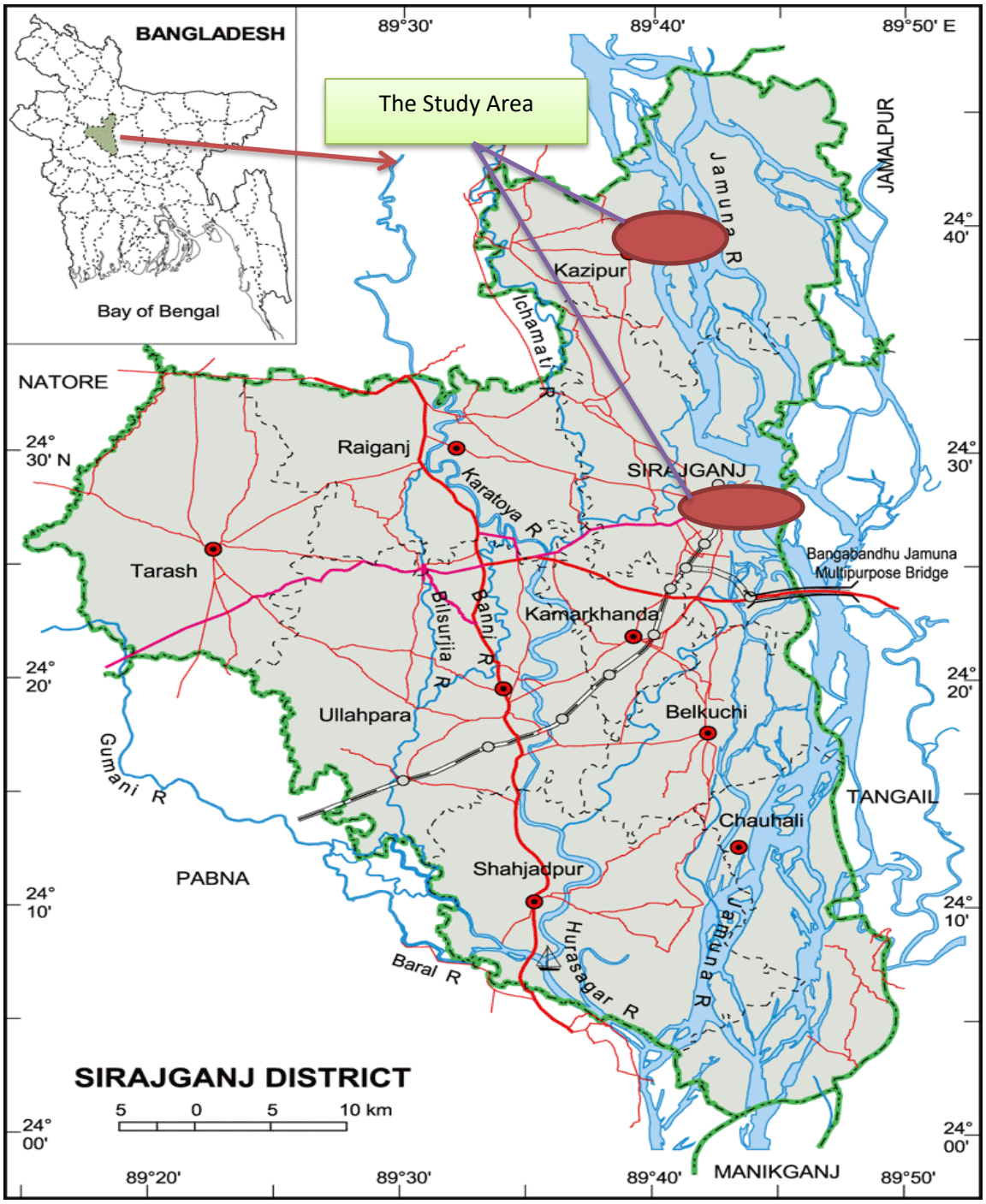

Figure 3. Map of Sirajganj District Showing the Study areas.
(Source: http://2.bp.blogspot.com/-q5)

3.2. Population

People who engaged in mixed farming and permanently reside in the selected village of Sirajganj Sadar and Kazipur Upazilas are constituted the active population of this study.As all population of the study area could not possible to measure, head of the farm families of mixed farming of the selected villages were the population of the study. The total number of mixed farming farmers in selected ten villages 178 which constituted the population of the study.

3.3. Determination of the sample size

The population size was 178.

Respondents were randomly selected as the sample of the study by using random number table. The sampling number was determined by using a standard formula. In calculating sample size 12% marginal error was chosen from the following formula (Moral, 2011). Thus the sample size is 50.

$$n = \frac{N}{1+Ne^2}$$

Where, n (Sample size) = 50

N (Population size) = 178

e (Marginal error) = 12%

3.4. Distribution of the population, sample size and reserve list

The respondents comprised of 50 farmers who conducted mixed farming. A reserve list of 30 respondents was also prepared so that, the farmers of this list could be used for interview if respondents included in the original sample were not available at the

time of interview. However, representative sample from the population were taken for the collection of data following proportionate random sampling technique.

Table 1. List of study areas in Sirajganj District

District	**Upazilas**	**Villages**	**Population size/village(No.)**	**Sample size/village(No.)**
Sirajganj	Sirajganj Sadar	Bagbati	17	5
		Pipulbaria	18	5
		Shyampur	17	5
		Chilgacha	18	5
		Char-Brahmagacha	18	5
	Kazipur	Gandhail	18	5
		Patta-Gram	18	5
		Singra-Bari	18	5
		Tenglahata	18	5
		Dublai	18	5
Total	2	10	178	50

3.5. The research instrument

Based on objectives of the study, a well-structured interview schedule was developed for collecting information with containing direct and simple questions in open form and close form keeping in view the dependent and independent variables. Appropriate scales were developed to measure both dependent and independent variables. Before finalize, the questionnaire was pre-tested with 5 homestead owners in actual situation for collection of data. Necessary corrections, additions, alterations, rearrangements and adjustments were made in the interview schedule based on pre-test experience. A questionnaire was then multiplied by printing in its final form.

3.6. Data collection procedure

The researcher herself collected the data from the sample respondents through personal contact with the help of a pre-tested interview schedule. Whenever any of the

respondents faced difficulty in understanding the questions, more attention was taken to explain the same with a view to enabling the respondent to answer properly. No serious problem was faced by the researcher during data collection, but obtained cooperation from the respondents. Data collection was started in 12 February 2017 and completed in 20 December 2017.

Plate 1. Data collection (plate: A, B, C and D) by researcher at different villages of Sirajganj.

3.7. Variables and their measurement techniques

Independent variables were age, family size, total land area, annual income, occupation, production, use of products and by-products, tree plantation along road

side, types and number of animal rearing, source and storage of livestock feed, types of feed at time of natural hazard, farmer's problem, environmental factors that affect tree-crop-livestock production etc. Dependent variables are appropriate choice of tree species, increase of income, and increase in production system etc. The methods and procedures in measuring the variables of this study are presented below-

3.7.1. Age

Age of the farmer was measured in terms of actual years from their birth to the time of their interview, which was found on the basis of the verbal response of the farmers. A score of one (1) was assigned for each age. If a farmer was 45 years old, his age score was assigned as 45.

3.7.2. Education

Level of education was measured in terms of class passed by the respondent farmer. If a respondent received education from school their education was assessed in terms of year of schooling. For example, if a farmer passed the final examination of class five (V), his/her score was taken as 5. Each illiterate person was given a score zero (0).

3.7.3. Family size

Family size of a farmer was determined by the total number of members of his/her family including him/her, children and other dependents. The scoring was made by the actual number of family members expressed by the farmers. For example, if a farmer had five members in his/her family, he/she was given score as 5.

3.7.4. Farm size

The term, farm size of a farmer referred to the total area of land on which his/her family carried out the farming operation, the area being in terms of fully benefit to the family. The data was first recorded as the local measurement unit, that is decimal and

then converted into acre. The total area thus obtained is called the total land area assigning a score for each acre.

3.7.5. Annual income

Annual income refers to the annual income of farmer and the members of his/her family from different sources. It was expressed in thousands taka. In measuring this variable, last year total earning of an individual farmer was taken and then converted into score. A score of 1 is given for each thousand taka.

3.7.6. Occupation

Occupation is an activity that serves as one's regular source of livelihood. Occupation is also said as an activity engaged in especially as a means of passing time and earning money. Different people have different occupation. Someone may be a farmer, someone be a teacher, a businessman and others. Data was taken from the farmers what was their actual occupation, whether only farming or farming besides other profession.

3.7.7. Production

Production is the process of making, harvesting or creating something or the amount of something that was made or harvested. Example of production is harvesting corn, paddy, oilseed, pulse etc. to eat. In collecting data, it was considered what the farmers produce in their land.

3.7.8. Use of products and by-products

It means how the farmers utilize the products, produced in their land. In collecting data, it also observed the utilization of the rest part of products, which the farmers do not use themselves.

3.7.9. Tree plantation along road side

It gave the answer that, whether the farmers planted trees along the road sides or not.

3.7.10. Types and numbers of animal rearing

It means what types of livestock the farmers keep in their farm and the number of rearing animals in farm. The number of the animal was expressed in the actual number. That is, 1 is given for each cow, 5 is for five cows etc. the scoring is same in terms of poultry.

3.7.11. Source and storage of livestock feed

The farmers mostly depend upon straw for their cattle. Besides straw whichtree leaves were given to the livestock were observed. Howthe farmers usually stored the straw for future use was also observed when data was collected.

3.7.12. Types of feed at the time of natural hazard

It refers to as what types of feed were given to the livestock when natural hazard occurred. At the time of natural hazard, there were shortage of animal feed, high price of market feed and sometimes it was difficult to store the feed.Then, what was the farmers' activity was observed during data collection.

3.7.13. Farmer's problem

Farmers face different problems during farming practice and rearing animals. Problems may be at the field, at market, during irrigation, during fertilizer application, livestock breeding, health treatment, feeding etc. What problems they actually faced were noticed at the time of data collection.

3.7.14. Environmental factors that affect tree-crop-livestock production

In Bangladesh, environmental condition does not remain the same through the year rather it changes in several time. At the time of data collection, it was noticed what were the environmental factors that affect and hamper the production of tree-crop and

livestock. What steps did the farmers take during adverse environmental condition were also observed.

3.7.15. Problem ranking

Ranking question calculate the average ranking for each answer choice so we can determine which answer choice was most preferred overall. The answer choice with the largest average ranking is the most preferred choice. It was also applied to ranking farmer's problem.

The average ranking is calculated by the following formula, where:

w = weight of ranked position

x = response count for answer choice

$$\frac{x_1w_1 + x_2w_2 + x_3w_3 + \ldots\ldots + x_nw_n}{\text{Total response count}}$$

Weights are applied in reverse. The respondent's most preferred choice (which they rank as #1) has the largest weight, and their least preferred choice (which they rank in the last position) has a weight of 1. We can't change the default weights.

3.8. Data Processing

Data processing is an on-going part of data collection. After completion of field survey, all the data were coded, compiled and tabulated according to the objectives of the study. Local units were converted into standard units. All the individual responses to the questions of the interview schedule were transferred in to a master sheet to facilitate tabulation, categorization and organization. In case of qualitative data, appropriate scoring technique was followed to convert the data into quantitative form.

3.9. Statistical analyses

Data collected from the respondents were analyzed and interpreted in accordance with the objectives of the study. The analysis of data was performed using statistical

treatment with SPSS (Statistical Package for Social Science) computer program, version 23. Statistical measures as a number, range, mean, standard deviation were used in describing the variables whenever applicable. Tables were also used in presenting data for clarity of understanding. Initially, Pearson Product Moment correlation was run to determine the relationship between the selected characteristics of the farmers with the interaction of tree-crop-livestock with environment. To find out the contribution of the selected characteristics of the farmers with the interaction of tree-crop-livestock with environment, step-wise multiple regressions were used. Five (5) percent level of probability was used as the basis for rejection of null hypotheses throughout the study. Co-efficient values significant at 0.05 level is indicated by one asterisk (*), and that at 0.01 level by two asterisks (**), and 0.001 level or above by three asterisks (***).

CHAPTER IV

RESULT AND DISCUSSION

4.1. Age

For the research work, the respondents were selected from different age. Table 1 shows the range of age of the respondents according to the categories.

Table 2. Distribution of the respondents according to their age

Categories(yrs)	Observed range(yrs)	Number	Percent	Mean	Standard deviation
Young age (< 35)	22-70	13	26	43.3	9.525
Middle age (36-50)		27	54		
Old age (> 50)		10	20		
Total		50	100		

From above table it is observed that, three categories of respondents were selected such as young age (whose age were below 35 years), middle age (whose age between 36 and 50 years) and old age (whose age above 50 years). The range was 22 years to 70 years old. The number of respondents belongs to young age were 13 (26 %), belongs to middle age were 27 (54%) and old age were 10 (20%). Average age was 43.3 years old and standard deviation was 9.525.

4.2. Education

The selected respondents were categorized according to their education level. There were four categories like primary, secondary, above secondary and no education.

Table 3. Distribution of respondents on the basis of level of education

Farm size	**Level of education of farmers****				**Total**	**Mean**	**Standa-rd Deviati-on**
	Primary	Secondary	Above Secondary	No Education			
Landless(0-0.49 acre)	7(39)	5(28)	1(5)	5(28)	18(100)	6.58	4.32
Small(0.50-2.49 acre)	7(30)	11(48)	2(9)	3(13)	23(100)		
Medium(2.50-7.49 acre)	2(25)	5(63)	1(12)	0(0)	8(100)		
Large(7.50 acre and above)	0(0)	0(0)	1(100)	0(0)	1(100)		
Total	16(32)	21(42)	5(10)	8(16)	50(100)		

**No. of respondent (% of total in parenthesis)

The table shows that, from the respondents, the number of landless farmers having primary education were 7 (39 %), secondary education were 5 (28%), above secondary education was 1 (5%) and no education were 5 (28%). Number of small farmers having primary education were 7 (30 %), secondary education were 11 (48%), above secondary education was 2 (9%) and no education were 3 (13%).Number of medium farmers having primary education were 2 (25 %), secondary education were 5 (63%), above secondary education was 1 (12%) and no education were 0 (0%).Number of large farmers having primary education were 0 (0 %), secondary education were 0 (0%), above secondary education was 1 (100%) and no education were 0 (0%). Where mean education level was 6.58 and standard deviation was 4.32.

4.3. Farm size

The respondents were categorized according to their farm size. The categories were-landless farmershaving land area 0 to 0.49 acre, small farmers having land area 0.50

to 2.49 acre, medium farmers having land area 2.50 to 7.49 acre and large farmers having land area 7.50 and above.

Table 4. Distribution of the respondents according to farm size

Categories	Number	Percentage (%)	Mean	Std. Deviation
Landless (0-0.49 acre)	18	36	1.841	1.587
Small (0.50-2.49 acre)	23	46		
Medium (2.50-7.49 acre)	8	16		
Large (7.50 acre and above)	1	2		
Total	50	100		

From the above table, it can be said that, number of landless farmers was 18 (36%), number of small farmers was 23 (46%), number of medium farmers was 8 (16%) and number of large farmers was 1(2%). Mean area was 1.8408 and standard deviation was 1.58704.

The average farm size of the study area (1.841) was higher than that of national average (1.48 acre) of Bangladesh (BBS, 2014).

4.4. Annual income

Annual income of the respondents was observed during data collection. The respondents were categorized according to income per month. Income was divided into four types like 2000-4000, 4000-6000, 6000-10000 and above 10000 per month respectively.

Table 5. Per month income of the respondents according to farm size

Categories	Per month income (Thousand Tk)**				Total Respondents
	2000-4000	4000-6000	6000-10000	>10000	
Landless	6(33)	8(45)	3(17)	1(5)	18(100)
Small	1(4)	12(53)	6(26)	4(17)	23(100)
Medium	0(0)	3(38)	4(50)	1(12)	8(100)
Large	0(0)	0(0)	0(0)	1(100)	1(100)
Total	7(14)	23(46)	13(26)	7(14)	50(100)

Landless (0-0.49 acre), Small (0.50-2.49 acre), Medium (2.50-7.49 acre) Large (7.50 acre and above)

** No. of respondent (% of total in parenthesis)

Table shows that, the numbers of landless farmers fall to the category 2000-4000 Tk were 6(33%), to the category 4000-6000 Tk were 8(45%), to the category 6000-1000 Tk were 3(17%) and to the category above 10000 Tk was 1(5%). The numbers of small farmers belongs to the categories 2000-4000 Tk, 4000-6000 Tk, 6000-10000 Tk and above 10000 Tk were 1(4%), 12(53%), 6(26%) and 4(17%) respectively.Numbers of medium farmers fall to the category 2000-4000 Tk were 0(0%), to the category 4000-6000 Tk were 3(38%), to the category 6000-1000 Tk were 4(50%) and to the category above 10000 Tk was 1(12%). The numbers of large farmers belongs to the categories 2000-4000 Tk, 4000-6000 Tk, 6000-10000 Tk and above 10000 Tk were 0(0%), 0(0%), 0(0%) and 1(100%) respectively.

4.5. Occupation

Most of the people of the villages were farmers, but there were other occupation among them.

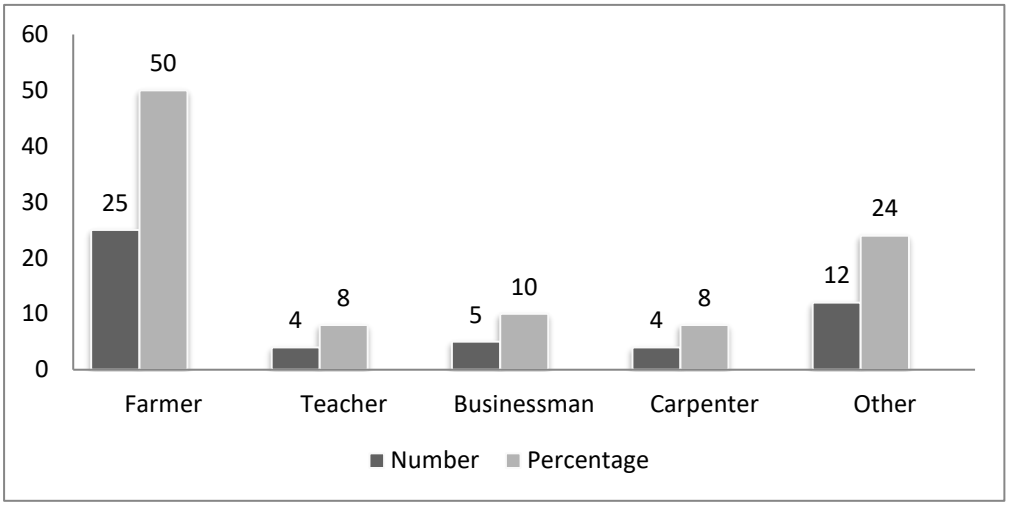

Figure 4. Number and percentage of respondents according to their occupation.

Figure shows that, 50% of the respondents were farmers. Another occupations including teacher 4 (8%), businessmen 5(10%), carpenter 4(8%) and others 12(24%). Although, the people who belongs to other occupation, they occupied in farming for their own consumption.

4.6. Agroforestry system

Different agroforestry system were observed in the research area, such as-

Agri-silvi culture, Silvopasture and Agro-silvopasture.

4.6.1. Agri-silvi culture:

It is defined as growing of trees and agriculture crops together in same lands at the same time. This system is common in all agro-ecological zones of Sirajganj. Mainly agricultural crops- rice, wheat, fodder grass were integrated with tree species like Mahagoni, Eucalyptus, Mango, Akashmoni etc.There were some advantages of this system: The system produced multiple products such as food/vegetables/fruits, fodder and forage needed for livestock, fuel wood, timber, and leaf litter needed for organic

manure production.This was also the best practice for soil nutrient recycling, which also helps to reduce chemical fertilizer purchase.

Plate 2. Agri-silvi cultural system in experimental areas (Source: Photo taken by the researcher)

4.6.2. Silvopasture:

Silvopasture (Latin, silva forest) is the practice of combining woodland (trees) and the grazing of domesticated animals in a mutually beneficial way. It is one of several distinct forms of agroforestry. In Silvopasture system, the trees are managed for high-value saw logs, brushwood, foliage, fodder, and, simultaneously provide shade and shelter for livestock and some forage, reducing stress and sometimes increasing forage production. Advantages of a properly-managed silvo-pasture were: operation was enhanced soil protection and increased long-term income due to the simultaneous production of tree and grazing animals.

Plate 3. Plate A and plate B showing Silvopastoral system in experimental areas. (Source: Photo taken by the researcher)

4.6.3. Agro-silvopasture:

The term agro-silvopastoral systems is a collective name for land-use systems involving the combination or deliberate association of a woody component (trees or shrubs) with crops and animal husbandry in the same site.The system was observed in the experimental areas of Sirajganj. The farmers integrated trees like Eucalyptus, Mehogoni, Mango, Banana etc. crops like rice, wheat and animals like cow, goat, sheep etc. Advantages of agro-silvo-pastoral systems: Diversification of production activities within the farm, reduction of risk of economic disasters. In addition to direct advantages, farmers also obtained economic benefits from fuel wood, timber, posts, and forage, which were used on the farm for cattle management.

Plate 4. Picture showing Agro-silvopastoral system in experimental areas.
(Source; Photo taken by the researcher)

Table 6. Agroforestry system and number of respondents practiced in the experimental areas

Practice	No. of respondents practiced	Percentage
Agri-silviculture	15	30
Silvopasture	10	20
Agro-silvopasture	25	50
Total	50	100

In south-east Asia and the south Pacific silvopastoral system was practiced such as plantation crops with pastures and animals: for example, cattle under coconuts. Agrosilvopastoral systems (animals, trees and crops). Homegardens involving animals: intimate, multistorey combination of various trees and crops, and animals, around homesteads (FAO, 2015).

4.7. Traditional Agroforestry Practices in the Areas

Different types of agroforestry were common in the early days. For many upland farmers, agroforestry was a way of life. Home garden, or homestead, is a common agroforestry system. In this system, tall trees are intercropped with medium shrubs

and short annual crops to produce a variety of foods and green manure besides reducing soil erosion. Intercropping in litchi plantations is also common. Farmers generally plant smaller trees such as papaya and banana underneath the palms. vegetables were found to grow in association with trees either under direct shade where food and cash generating plants and the associated fruit trees were Jackfruit, Mang and Litchi etc. The creeper vegetables grown on the trees were sponge gourd, ribbed gourd, country bean, bitter gourd; sweet gourd and most common host plant were jackfruit, mango, coconut, jujube etc. Fruit tree based agroforestry practices were-

- Mango based agroforestry practice,
- Jackfruit based agroforestry practice and
- Litchi based agroforestry practice etc.

Table 7. Major fruit tree species in association with vegetables in homestead agroforestry

Fruit tree	Vegetable grown under tree	Climber vegetable	No. of respondent associated
Jackfruit	Aroids, Turmeric, chili	Sponge gourd, Country bean	28
Mango	Amaranth, Indian spinach, Aroids	Sponge gourd, Bitter gourd	12
Litchi	Amaranth, Reddish	Country bean, Sweet gourd	10
Total			50

4.8. Production

Production is a process of combining various material inputs and immaterial inputs (plans, know-how) in order to make something for consumption (the output). It is the act of creating an output, a good or service which has value and contributes to the utility of individuals.

Production process means all economic activities that aim directly or indirectly to satisfy human wants and needs.

The respondents produced different products for their own consumption and sold the surplus to the market to earn money and meet family needs.

Table 8. Number of the respondents according to the production of different products

Number of farmers**	Types of crop produced					
	Cereal	Oilseed	Vegetable	Fodder crop	Pulse	Fiber crop
42 (84)	✓		✓	✓		
4 (8)	✓	✓		✓	✓	
3 (6)	✓			✓	✓	
1 (2)	✓	✓				✓
Total: 50(100)						

** No. of respondent (% of total in parenthesis)

From the table, it was known that 42 (84%) respondents were involved in the production of cereal, vegetables and fodder crops. 4 (8%) respondents produced cereal, oilseed, fodder crop and pulse. 3 (6%) respondents produced cereal, fodder crop and pulse and 1 (2%) respondents involved in the production of cereal, oilseed and fiber crop. From the table, it was observed that most of the farmers produced fodder crops for their cattle. Babul (2005) in his experiment showed that, 30% people produced only cereal, where 9% produced cereals and other crops in Mymensingh.

4.9. Products and by-products

The products produced in the farmers' field mainly used as their daily consumption. Besides consumption the surplus of the products of tree and crop (cereal, pulse, fiber, oil seed and vegetables) were sold in the local market. By selling the farmers earned some extra money to meet their necessities. The by-products of the tree and crops

were used as animal feed such as rice bran, straw, oil cake, waste and unused parts of vegetables etc.

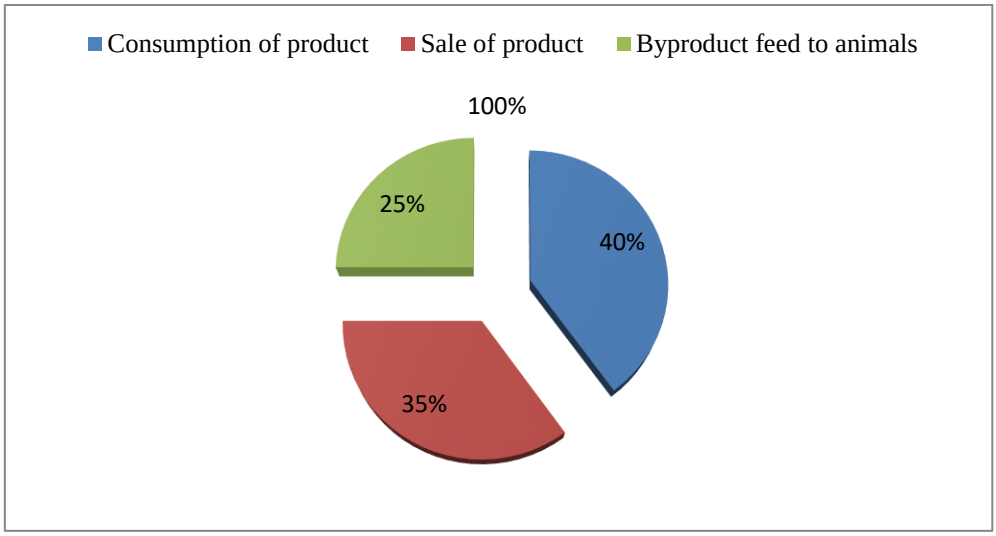

Figure 5. Uses of products and by-products with their percentage.

4.10. Types of tree species planted on the farmer's farm

The farmers planted different tree species on their farm. The plant species include fruit, timber, fuel, medicinal, boundaries, conservation of soil, selling purpose etc. types and names of the tree species are given below-

4.10.1. Fruit tree:

The study identified more or less 20 species of fruit trees in the experimental area. The most diverse number of tree species was observed in the homestead's orchards. The fruit trees include Mango, Jackfruit, Berry, Litchi, Wood Apple, Grapefruit, Pomegranate, Custard Apple, Plum, Carambola, Tamarind, Jamrul, Guava, Banana, Coconut, Papaya, Hog-plum, Acid fruit, Lemon etc. Also the leaves of Coconut were used for house construction and making of mats.

Table 9. Fruit trees and number of respondents occupied the tree species

Name of fruit tree	Scientific name	Number of respondents occupied	Percentage (%)
Mango	*Mangifera indica*	42	84
Jackfruit	*Artocarpus heterophyllus*	40	80
Guava	*Psidium guajava*	35	70
Coconut	*Cocos nucifera*	30	60
Banana	*Musa sapientum*	32	64
Lemon	*Citrus limon*	25	50
Papaya	*Carica papaya*	35	70
Tamarind	*Tamarindus indica*	10	20
Wood apple	*Aegle marmelos*	15	30
Custard apple	*Annona reticulata*	10	20

From the table, it was observed that mango and jackfruit were occupied by maximum respondents. Banana, coconut, papaya and guava were next to mango and jackfruit.

4.10.2. Timber tree:

Due to the durability of certain tree species and the market value of timber, farmers integrated these on their farms. They are used in the construction or maintenance of their houses and moreover sell to increase the revenue level of the family. Some of the timber species trees found on farmers' plots was Mehogoni, Eucalyptus, Teak, Accacia (Akashmoni), Sissoo, Rain tree, Babla etc.

Table 10. Timber tree species and number of respondents occupied

Timber tree	**Scientific name**	**Number of respondents occupied**	**Percentage (%)**
Mehogoni	*Swietenia macrophylla*	45	90
Eucalyptus	*Eucalyptus camaldulensis*	48	96
Teak	*Tecktona grandis*	20	40
Akashmoni	*Acaccia auriculiformis*	15	30
Babla	*Acaccia nilotica*	5	10

From the table it was seen that, maximum respondents planted Mehogoni and Eucalyptus for their timber purpose. Teak was planted less than Mehogoni and Eucalyptus. Very few respondents planted Babla.

4.10.3. Fuel wood tree:

Fuel wood can be collected from most of the tree species. All fruit tree and timber tree produce fuel wood. Besides these Jiga, Fig, Bamboo, Eucalyptus, Mahagoni etc. were used.

4.10.4. Boundary tree:

Boundary tree found in the area were Betel nut, Coconut, Palm, Eucalyptus etc. Coconut was also planted around pond.

4.10.5. Medicinal tree:

Neem, Wood Apple, Pomegranate, Guava, Arjun, etc. were used by the farmers as medicinal tree in their different problem. Leaves, twig, bark, root, bark of root etc. parts of the trees were used.

Table 11. A list of boundary and medicinal tree species

Tree Species	Scientific name	Number of respondents planted	Percentage (%)
Neem	*Azadirachta indica*	25	50
Wood apple	*Aegle marmelos*	15	30
Pomegranate	*Punica granatum*	10	20
Coconut	*Cocos nucifera*	35	70
Betel nut	*Areca catechu*	25	50
Eucalyptus	*Eucalyptus camaldulensis*	48	96

Table 11 shows that most of the respondents planted Eucalyptus and Coconut. Few respondents planted Pomegranate and Palm tree.

4.10.6. Fodder tree:

Tree species used as fodder include Jackfruit, Mango, Carambola, Bamboo etc. Although this were not regular feed of animals but used only when it was required.

4.11. Uses of planting tree

Depending on the needs of the farmer certain species of trees were planted or retained on farm. Provisioning and environmental services of trees were highly valued by the farmers. Table shows that the tree species recorded during the study along with their utilities, products and services. Trees provided key products which were either sold to raise the income levels of the households or used directly. A majority of the trees identified performed multiple functions.

Table 12. Name and uses of different tree species grown in the research areas

Types of tree	Uses of common tree species						
	Fruit	Fodder	Timber	Fuel	Medicine	Boundary	Soil conservat-ion
Mango	X		X	X			
Jackfruit	X	X	X	X			X
Coconut	X			X		X	X
Neem				X	X		X
Mehogoni			X	X		X	
Eucalyptus			X	X		X	X
Bamboo		X		X			

X indicates the use of tree

Table shows common tree species and their uses. Among the tree species Mango, Jackfruit, Coconut, Neem, Mahagoni, Eucalyptus and Bamboo was mentioned.

- Mango was grown for fruit, timber, fuel wood and other purposes.

- Jackfruit was grown for fruit, fodder, timber, fuel wood, soil conservation and other purposes.
- Coconut is mainly grown for fruit but it also used for fuel, boundary tree, soil conservation and someone made carpet, broom, from its leaves and rachis of leaves whereas neem was planted for its medicinal uses. It also acts as soil conservation.
- Mahagoni was grown for its good quality timber. Also used for fuel and other purposes.
- Eucalyptus was good quality timber. It also provided fuel wood and planted as boundary tree.
- Bamboo mainly needed for house construction. Its leaves were provided to the cattle as fodder, branches of bamboo used as fuel, making fence etc.

4.12. Tree species used in environmental service: To conserve the soil of land and to protect the soil from washed away, the farmers planted different tree species on the dike of field, bank of river and pond and also in homestead land.

Table 13. Environmental services of tree

Tree Species	Environmental Services of Tree				
	Wind break	Soil erosion control	Nutrient cycling	Humidity and Shade	Air purification
Jackfruit	×			×	
Mango		×	×	×	
Neem	×	×	×	×	×
Eucalyptus	×	×			
Akashmoni	×	×	×		×
Coconut	×	×			×
Litchi	×	×		×	×

× indicates the services of the tree

Toth (2007) said that, in Gambia the enhancement of home gardens would simply involve the planting of more vegetables, cereal crops and also enhance through the incorporation of green manure cover cropping which involves the growing of nitrogen fixing species to be incorporated back into soil, as a means of maintaining soil fertility.

4.13. Tree species used in selling purpose: Mainly Eucalyptus and Mehogoni were planted for this purpose. The farmers thought that, Eucalyptus grew faster than other species of plant. Many farmers planted Eucalyptus in their garden. After 10-12 years of plantation the trees were ready for use. For construction it required above 20 years. It was used as fuel purpose, construction materials like poles and stakes for the construction of house, fencing, transmission pole, farm equipment etc. which required time from other species of plant.

Plate 5. Plate A showing Eucalyptus plantation on the bank of river (dried) and plate B showing a garden of Eucalyptus and some newly planted Mehogoni beside a fodder field.

4.14. Plantation of tree along road side

Farmers planted trees along the road side for different purpose such as- for shade, sale, soil conservation and so on. They thought road side plantation could add some extra income after a particular time. They also thought, in the hot summer the roadside trees spread their branches and leaves and give a cools shade for the pedestrians. The trees also give shade to cool the long running vehicles, which can be parked under the trees conveniently. Road side trees with their rich foliage can act as umbrella during rains. Sometimes the trunk of the tree grows in a curvature which is a sure cover in rains for the pedestrians. Roadside trees prevent many accidents. In rainy seasons, the side bund of roads become wet, and give away when a heavy vehicle pass on them by mistake in nights or when visibility is low. This happens while giving way for another vehicle also.

Table 14. Number and percentage of farmers who were involved road side plantation

Activity	Number of respondents	Percentage
Yes	28	56
No	22	44
Total	50	100

Table shows that, among 50 farmers 28 (56%) farmers planted trees along road side and 22 (44%) farmers did not planted along road side.

Importance of road side plantation for environment

There were many importance of roadside plantation.

Table 15. Importance of roadside plantation

Importance of tree	**No. of respondent complied**
Trees supply oxygen	44
Trees reduce greenhouse effect	12
Trees reduce noise pollution	6
Other benefits of road side trees	15

4.15. Types and numbers of animal rearing

All types of farmers such as, landless, small, medium and large rear animals for consumption and sale. Someone may have only cow, someone may have only poultry or other may have both cattle and poultry.

Table 16. Number of respondents according to the categories with their rearing animals

Types of animal reared	Number of respondents according to categories				Total respondent
	Landless	Small	Medium	Large	
Cow	18	23	8	1	50(50)
Goat	7	9	5	0	21(50)
Sheep	3	2	1	0	6(50)
Hen	18	21	8	1	48(50)
Duck	4	3	2	0	9(50)

Farmers categories: Landless (0-0.49 acre), Small (0.50-2.49 acre), Medium (2.50-7.49 acre), Large (7.50 acre and above).

Table showed that, landless category- 18 (18) respondents had cow, 7 (18) had goat and 3 (18) had sheep. 18 (18) person rears hen and 4 (18) rears duck. In small category- 23 (23) had cow, 9 (23) had goat and 1 (23) had sheep. 21 (23) farmer rear hen and 3 (23) rears duck. In medium category- 8 (8) respondents had cow, 5 (8) had goat and 1 (8) had sheep. Hens were reared by 8 farmers and duck by 2 farmers. In category large, 1(1) farmer rear cow and hen.

4.16. Purpose of animal rearing

Different farmers have different purpose of cattle rearing.

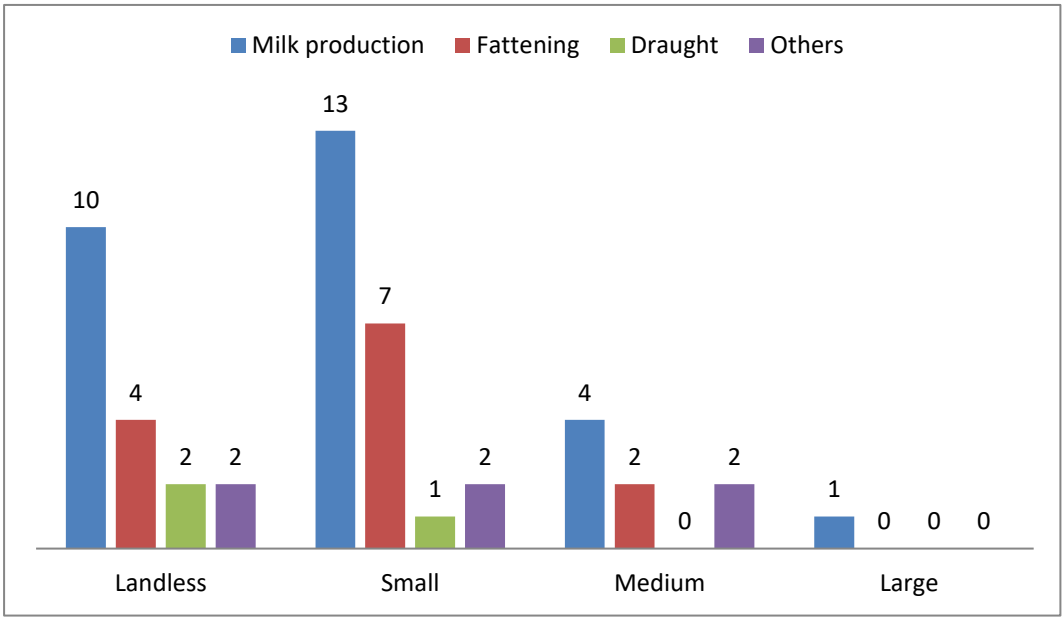

Figure 6. Number of farmers according to purpose of animal rearing with categories.

Farmers categories: Landless (0-0.49 acre), Small (0.50-2.49 acre), Medium (2.50-7.49 acre), Large (7.50 acre and above).

From the above figure we know that, among the categories, in landless farmers- number of farmers rear cattle for milk production was 10 (55%), number of farmers rear cattle for fattening was 4 (23%), number of farmers rear cattle for draught was 2(11%) and number of farmers rear cattle for other purpose was 2(11%).

In case of small farmers the number of farmers rear cattle for milk production, for fattening, for draught and other purpose was 13(56%), 7(31%), 1(45) and 2(9%) respectively.

In case of medium farmers, the number of farmer rear cattle for milk production was 4(50%), for fattening was 2(25%), for draught was 0(0%) and for other purpose was 2(25%).

In large farmers, 1 (100%) farmer rear cattle for milk production.

An analysis of Babul (2005) in Mymensingh showed that, 36% people rear cattle for milk production, 28% for drought and 3% for fattening in his area.

4.17. Source and storage of animal feed

Animal feed can be classified into three main types: (1) roughages, (2) concentrates, and (3) mixed feeds. Roughages include pasture forages, hays, silages, and byproduct feeds that contain a high percentage of fiber. Concentrates are the energy-rich grains and molasses, the protein- and energy-rich supplements and byproduct feeds, vitamin supplements, and mineral supplements. Mixed feeds may be either high or low in energy, protein, or fiber; or they may provide "complete" balanced rations.Some farmers also gave unused and waste parts of vegetables.

Table 17. Source of animal feed in the experimental areas the farmers provided to their animals

Types	Respondents use	Example of source
Roughages	10	Straw of rice and wheat, green grass
Concentrates	15	Broken rice, rice bran, mustard oil-cake, molasses, and byproducts of pulses
Mixed feed	25	Straw, grass, broken rice, molasses, mustard oil-cake, salt, vitamin and mineral supplement mixed together to make a complete balanced feed for the cow, goat, and sheep

For poultry, the farmers provide broken rice, rice bran, wheat, paddy and byproducts of rice, wheat and pulse etc. In the experimental areas, maximum poultry were scavengers as they were feed mostly in the morning.

Plate 6. The two pictures show the production of cattle grass on the farmers own field. (Source: Collected by the researcher)

Storage system means to preserve any product for future use. Most of the farmers in the experimental areas stored their rice straw in hay pile.

Plate 7. A hay pile showing storage of straw. (Source: Collected by the researcher)

From Babul (2005) in Mymensingh it was observed that, 29% farmers used hay pile for storing straw.

4.18. Types of feed at the time of natural hazard

The farmers were in trouble at the time of natural hazards such as flood, drought, storm, hailstorm, river bank erosion etc. Poor people suffered much to feed their animal as the price of all product rose. Nevertheless they had to provide their pet. The farmers supplied straw from pile, preserved rice bran, mustard oil-cake and vegetable parts. They also bought animal feed from market. At the time of flood the farmers could not provide green grass as most of the grass field was flooded so they provide tree leaves to their livestock. The farmers provided leaves of jackfruit, bamboo, mango, carambola etc.

Table 18. Types and sources of feed at the time of natural hazard

Feed types	Sources	Respondent use
Concentrate	Rice bran, broken rice, mustard oil cake	15
Roughage	Green grass, straw	28
Leaves	Leaves of jackfruit, mango, guava, bamboo	7

4.19. Interaction among tree-crop-livestock and environment

In the study area, interactions among tree-crop-livestock with environment were observed with the help of respondents. Results were shown in in the tables below-

Table 19. Tree-crop interaction in the study area

Positive interaction	Citation No.	Negative interaction	Citation No.
Nutrient that taken up in the top soil by tree root can easily uptake by crop	22	Shading by the trees, reducing light intensity at the crop level	25
Litter/mulch decomposes and make nutrients available for tree and crop	42	Root competition between tree and crop for space	15
Optimum utilization of water, fertilizer etc.	12	Tree and crop can be host of each other for pest and diseases	10

From the table, it was observed that, 22 respondents were concerned about the positive interaction of tree and crop as nutrient uptake, 42 respondents concerned about litter decomposition etc. On the other hand the respondents knew that negative interaction included shading, root competition etc.

Table 20. Tree-livestock interaction in the study area

Positive interaction	Citation No.	Negative interaction	Citation No.
Toxic or deterrent compound can be extracted and used for pest control, such as azadirachtin in the neem tree	22	Toxic components within, tree fodder can adversely affect livestock production	15
Livestock frequently take advantage of the shade provided in wooded sites	35	Many species contain secondary compounds that reduce the feed value	5
Tree leaves are provided as livestock fodder	40	Digestibility can be low and the leaves may contain toxins	10

Table showed that, positive interaction between tree and livestock included toxic compound extraction from tree that helped in controlling pest, shade provided to livestock etc. Negative interaction showed toxicity and digestibility, adverse effects of tree leaves etc.

Table 21. Tree-environment interaction in the experimental area

Positive interaction	Citation No.	Negative interaction	Citation No.
Tree produce oxygen that keeps environment livable	48	Adverse environment reduce production of tree	42
Trees reduce temperature	25	Tree production required inorganic fertilizer that pollute soil and water	35
Trees save soil from erosion	40	Sometimes pollen and small seed from tree cause air pollution	15

From the table, it was known that the respondents known about tree-environment interaction. Positive interaction included production of oxygen, reduction of soil erosion etc. whereas negative interaction included reduction of tree production in adverse environment, production of pollen caused air pollution.

Table 22. Crop-environment interaction in the study area

Positive interaction	Citation No.	Negative interaction	Citation No.
Crop residues mixed with soil and increases soil fertility	40	Crop production required tillage that influence soil erosion by rain	10
Fertile soil required less inorganic fertilizer	38	Inorganic fertilizer polluted soil and water	45
Soil covered with crop reduces soil from washing away	44	Submerged crop produce methane gas	5

The respondents thought that, positive interaction between crop and environment included increasing of soil fertility due to mixing of crop residue with soil which reduced use of inorganic fertilizer. Negative interaction included pollution of soil and water due to use of inorganic fertilizer.

Table 23. Livestock-environment interaction in the experimental area

Positive interaction	Citation No.	Negative interaction	Citation No.
Land saving due to recycling of agricultural by products as animal feed	25	Emission of greenhouse gases to the environment	12
Use of dung- cake as domestic fuel	14	Overgrazing and deforestation	28
Saving of chemical fertilizers due to use of dung as manure	11	Water pollution	10

From the table it was known that, the respondents were concerned about positive and negative interaction between livestock and environment. 25 respondents said that positive interaction was recycling of agricultural by products as animal feed, 11 respondents said that use of cow dung saved chemical fertilizer. 28 respondents thought that negative interaction included overgrazing and deforestation.

4.20. Farmers' opinion: Farmers provide their opinion on whether there was any interaction among tree-crop-livestock with environment-

Table 24. Farmers' opinion about interaction among tree-crop-livestock with environment

Farmers' opinion	Number of respondents
Yes	35
No	10
No comment	5
Total	50

From the table, it was found that among 50 respondents 35 respondents thought that there was interaction among tree-crop-livestock with environment. 10 respondents thought that, there was no interaction among tree-crop-livestock with environment. 5 respondents did not have any comment about this.

4.21. Environmental factors that effect tree-crop-livestock production

Though the environment was conducive to farming, there were many environmental factors that affect the production of tree-crop and livestock. The factors include flood, storm, drought, river bank erosion, temperature variation etc.

Table 25. Different environmental factors and their effects

Name of factors	No. of respondents complied
Flood	48
Storm	24
Drought	22
River bank erosion	38
High temperature	30

4.22. Farmer's problem

At the time of conducting mixed farming, the farmers faced many problems.

Table 26. Problem faced by the respondents at the time of crop production

Description of the problem	Problem ranking
Problem of getting good quality plant seed and crop seed	1
Irregular supply and high price of fertilizer	2
Lack of irrigation facilities	3
Lack of training facilities farming	12
Lack of co-operation from AEO	6
Problem on livestock grazing on plant and crop field	13
Lack of credit facilities and the farmers had to pay high rate of interest	4
Lack of proper treatment of livestock and poultry	7
High price of veterinary medicine	8
Balanced feed cost is high	10
Lack of high yielding breed	9
Lack of supply of livestock support service	14
Soil erosion problem	5
Limited marketing opportunities	15
Lack of knowledge, information, and advisory services	11

The table informed that, the farmers' no. problem was they did not get good quality plant or crop seed for production. Other problems were irregular supply and high price of fertilizer, lack of irrigation facilities, soil erosion problem etc. (Source: Galhena et al., 2013).

4.23. Farmers' suggestion

Farmers had some suggestion according to their problems of mixed farming and production.

Table 27. Suggestion which would make their farming easier were compiled

Farmer's suggestion	**No. of respondent suggested**
Ensure quality seed of tree and crop	40
Reduce fertilizer price	35
Reduce irrigation cost	42
Interest free credit	35
Reduce soil erosion problem by taking necessary steps	30
Available service for livestock and poultry	18
Co-operation from AEO	15
Low cost medicine	40
Production of high yielding breed	41
Reduction the rate of balanced feed	32
Co-operation from Govt. and local NGOs	20
Provide training facilities	25

The farmers suggested that, they could produce more crop and they would be able to get more money from crop and livestock if they could ensure quality seed, fertilizer and irrigation cost was reduced, production of high yielding breed etc.

4.24. Factors that motivated people to use mixed farming in the experimental areas

There were different factors that motivated the respondents to adopt and use mixed farming.

Table 28. Various motivational factors and the number of respondents adopted

Factors motivated	Number of respondents	Percentage
Having sufficient food throughout the year	25	50
Getting income	12	24
Having diverse products	8	16
Helps in life risks reduction	5	10
Total	50	100

From the table, it can be seen that, majority of the respondents used mixed farming for having sufficient food throughout the year, some respondents used for getting and increasing income and others for reducing risk depending on single crop.

4.25. Relationship of the selected characteristics of Tree-crop-livestock with environment and some independent variables

Table 29. Pearson's product moment co-efficient of correlation showing relationship between dependent and independent variables-

Dependent variable	Independent variables	Tabulated 'r' value		Value of co-efficient of correlation	
		0.05 level	0.01 level	'r' Value	Significance
Tree-crop-livestock with environment	Farm size	0.279	0.361	0.047	0.747**
	Livestock			-0.259	0.069
	Income			0.043	0.567**
	Production			0.195	0.674**
	Road side plantation			-0.012	0.934**

4.25.1. Farm size and tree-crop-livestock with environment

Relationship between farm size of the farmers and tree-crop-livestock with environment was determined by Pearson product moment of correlation coefficient.

From the table it was observed that, value of coefficient of correlation between farm size and tree-crop-livestock with environment was found 0.047 with (n-2) = 48, degree of freedom. It means that, there was a positive correlation between farm size and tree-crop-livestock with environment as increased farm size, increased the interaction. It also showed that, it was an intermediate correlation as it was between 0.25 and 0.75. Now, the significant 2-tailed gave the 'r' value 0.747 which was higher than the tabulated value 0.279 at 5% level of significance and also higher than the value 0.361 at 1% level of significance. So, alternative hypothesis could be accepted.

It can be said that, there was a statistically significant relationship between farm size and tree-crop-livestock with environment.

4.25.2. Numbers of livestock and tree-crop-livestock with environment

Relationship between numbers of livestock of the farmers and tree-crop-livestock with environment was determined by Pearson product of correlation coefficient.

It was observed that, the coefficient 'r' value was found -0.259 with (n-2) = 48, (n=50) degree of freedom. The value showed that, there was a negative correlation between numbers of livestock and tree-crop-livestock with environment. The significant 2-tailed gave the 'r' value 0.069 which was lower than the tabulated value 0.279 at 5% level of significance. So, it can be concluded that, there was no significant relationship between and tree-crop-livestock with environment.

4.25.3. Income of the farmers and tree-crop-livestock with environment

Relationship between income of the farmers and tree-crop-livestock with environment was determined by Pearson product of correlation coefficient.

From the table it was known that, the coefficient value was 0.043 with (n-2) = 48, degree of freedom. It means there was a positive correlation between income of the farmers and tree-crop-livestock with environment. The value represented a weak correlation as it was less than 0.25. Now, the significant 2-tailed gave us the 'r' value 0.767 which was higher than the tabulated value 0.279 at 5% level of significant and also higher than the tabulated value 0.361 at 1% level of significance. So, based on above findings it can be said that, there was a statistically significant relationship between income of the farmers and tree-crop-livestock with environment.

4.25.4. Production of the farmers and tree-crop-livestock with environment

Relationship between production of the farmers and tree-crop-livestock with environment was determined by Pearson product of correlation coefficient.

It was observed that, the coefficient value was 0.195 with (n-2) = 48, (n=50) degree of freedom. The value represented a positive correlation between production of the farmers and tree-crop-livestock with environment as increased the production of the farmers increased the interaction. It also showed a weak correlation as it was less than 0.25. Now, the significant 2-tailed gave us the 'r' value 0.674 which was higher than the tabulated value 0.279 at 5% level of significant and also higher than the tabulated value 0.361 at 1% level of significance. So, based on above findings it was said that, there was a statistically significant relationship between production of the farmers and tree-crop-livestock with environment.

4.25.5. Road side plantation and tree-crop-livestock with environment

Relationship between road side plantation undertaken by the farmers and tree-crop-livestock with environment was determined by Pearson product of correlation coefficient.

It was observed from the table that, the coefficient value was found -0.012 with (n-2) = 48 (n=50) degree of freedom. The value showed that, there was a negative correlation between numbers of livestock and tree-crop-livestock with environment. The significant 2-tailed gave the 'r' value 0.934 which was higher than the tabulated value 0.279 at 5% level of significance and also higher than the tabulated value 0.361 at 1% level of significance. So, from the above findings it was concluded that, there was a significant relationship between road side plantation undertaken by the farmers and tree-crop-livestock with environment.

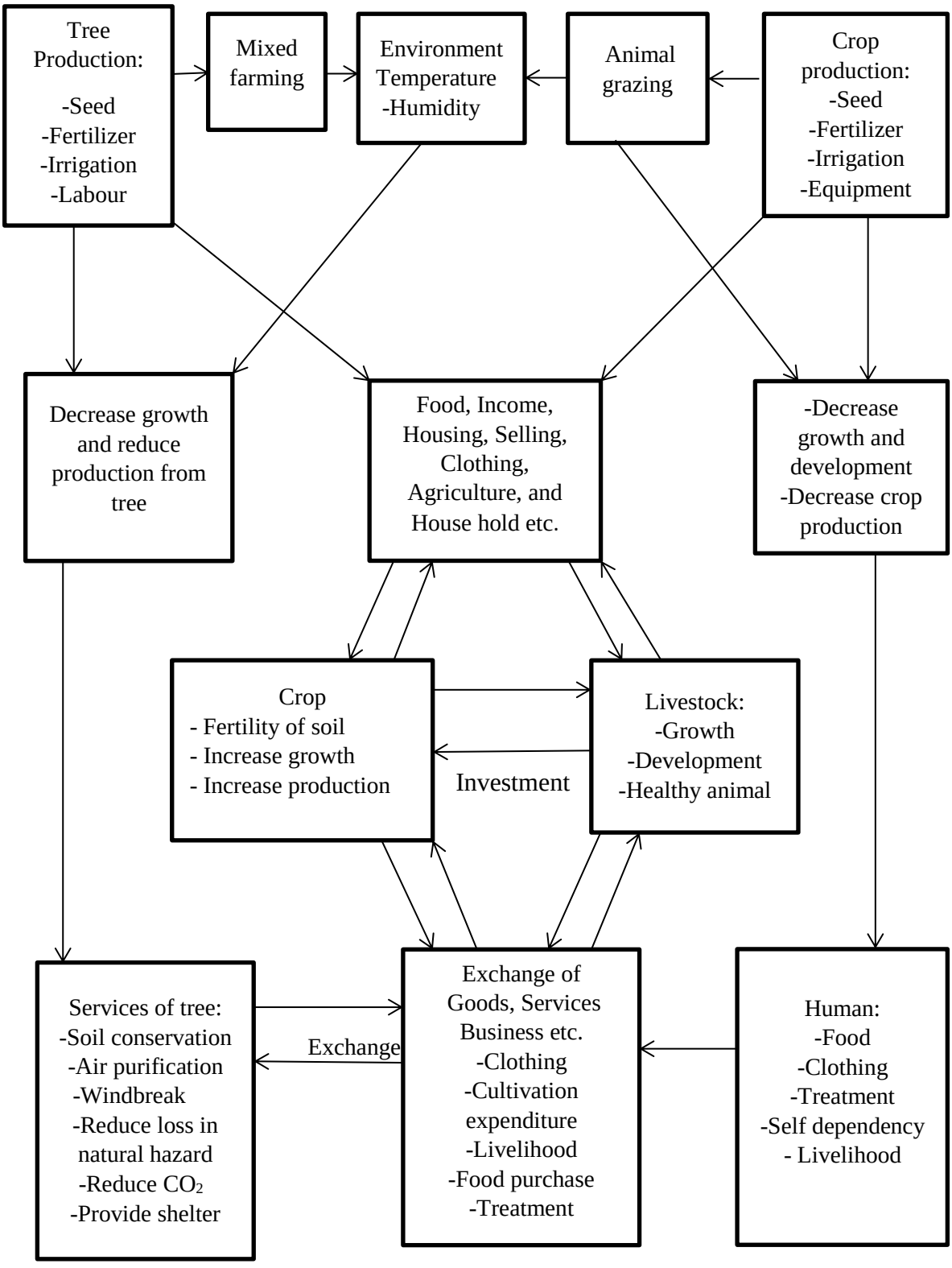

Figure 7. Tree-crop-livestock and environmental interaction in the experimental areas of Sirajganj.

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY

In this study the relationship among tree-livestock-environment in Sirajganj was focused mainly. To what extent the farmers of this area use tree or feed their livestock with the support from tree was also illustrated. It also brought out the information about the choice of the farmers whether they were satisfied with the crop feed or tree feed. As trees are for longer term economic productions, if they could be used as the food for livestock, they would sure to contribute lot in annual economic productions. The result of this study would be helpful for the farmers of this area as we may know the current level of food they collect from trees and also the best species of trees that are better for food and other production.

To improve tree-crop-livestock interactions achieving agro-ecological intensification came with challenges such as continuous degradation of forest. Farmer's harvested wood for construction, increased cattle on farm favored erosion through soil compaction. Cattle diseases occurred due to lack of veterinary personnel increased. Competition increased for nutrients and sunlight between trees and crops. Farmers had a wealth of knowledge about trees-crop-livestock interactions, trees and the various ecosystem services provided by trees. This coupled to their household needs greatly influence their planting and retention on their plots. There was a variation in the need of farmers and as a result farmers adopted different species of trees on their plots ranging from fertilizing trees, fruit trees, timber species and fodder trees. Also,

all farmers had detailed knowledge about fodder trees, fodder quality and the effect of fodder on the quality of milk and the general health of the cow.

In order to identify the opportunities and constraints to promoting agro-ecological intensification, the local knowledge of farmers should be examined to identify differences. Incorporating trees on farms had been demonstrated to increase incomes of poor families and asset bases, boost farmers yields while complementing crop and livestock production and maintaining or enhancing ecosystem services. Limited farm sizes had caused intensive exploitation of the natural resources base leading to decrease soil fertility, erosion and decreased productivity. Food security was threatened due to insufficient agricultural production caused by increasing population. There was therefore need for rapid innovation following the limitation and consequences of extensive agriculture. So there was needed to take into account the local context before implementing actions to the establishment or improvement of agroforestry systems. This study would therefore make use of the local knowledge of farmers to understand the tree-crop-livestock interactions on small holder farms and advice on which agroforestry practices best for sustainable agro-ecological intensification.

CONCLUSION

There were three types of agroforestry system found in the study area that is Agri-silviculture, Silvopasture and Agro-silvopasture. Where maximum number of the respondents practiced Jackfruit based agroforestry. The respondents got different types of production from tree, crop and livestock which were used for their own consumption and surplus was sold. Statistically significant positive interaction was found between tree-crop-livestock with environment and farm size (0.747), income (0.567), tree-crop production (0.674) respectively.

The most important problem was problem of getting good quality tree and crop seed, high price of fertilizer and lack of irrigation facilities etc. The respondents suggested that, if they got good quality seed, increase irrigation facilities, reduce the price of fertilizer and other necessary materials etc. they would be able to reduce the cost of production.

Limitation of the study

Considering the usual problem of conveyance, time, physical facilities and co-operation of the respondents, any scientific investigation undertaken by a student face and to make the study manageable and meaningful, it become necessary to impose certain limitation as mentioned below:

1. The study was confined to only two upazillas namely Sadar Upazila and Kazipur Upazila of Sirajgang District which may fail to represent the actual picture of the whole situation as people develop their strategies according to the concrete situation they face.
2. It is difficult to get exact information from the farmers as many of them are not enough educated.
3. There were awkwardness situation at the data collection time. So the researcher had to form proper rapport with the interviewees to collect actual response.
4. The population of the study was kept confined to the heads of the family who regularly cultivated their land
5. There were many characteristics of the farmers, but in the study only few of them were selected for the investigation due to the fewness of the research time
6. For information about the study, the researcher depended on the data furnished by the selected respondents during their interview
7. Major information, facts and figures supplied by the respondents were applicable to the situation prevailing in the locality during the year 2017.

CHAPTER VI

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CHAPTER VII

APPENDIX I.

A COPY OF AN INTERVIEW SCHEDULE (QUESTIONNAIRE)
DEPARTMENT OF AGROFORESTRY AND ENVIRONMENTAL SCIENCE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY, DHAKA- 1207

An interview schedule for a research study entitled
Tree-Crop-Livestock Interaction with Environment in the Rural Areas of Sirajganj

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Questionnaire:

1. i. Please mention your Name-
   Gender: Male ……. Female…….
   ii. Present Age- …….
   iii. Educational Qualification-
   a) Can't read and write
   b) Can't read and write but can sign only
   c) I have passed class…….
   iv. Family size
   a) How many members in your family……
   b) Earning members……
   v. Income per month: - <2000 tk
   - 2000-4000 tk
   - 4000-6000 tk
   - 6000-10000 tk
   vi. Occupation:

Source of Income	Amount	Percentage
unemployment		
Farming		
Business		
Others		

vii. Farm size: a) Landless- 0-0.49 acre
b) Small- 0.50-2.49 acre
c) Medium- 2.50-7.49 acre
d) Large- 7.50 and above

2. What are the traditional agroforestry systems in your area?
   a) Name of fruit tree …….
   b) Name of the vegetables grown under fruit trees……
   c) Name of the climber vegetables grown……..

3. What kind of agroforestry system you practice?
   -Why?

4. Types of crop produce:
   i) Cereal
   ii) Oil seed-
   iii) Vegetables-
   iv) Fiber crop-
   v) Pulse-
   vi) Tuber crop-
   vii) Fodder crop
   viii) Others-

5. Uses of crop products and by-products-
   a) Daily consumption
   b) Sale
   c) Handicraft
   d) Others

6. Types of trees planted:

   Fruit tree-
   Timber tree-
   Nut tree -
   Medicinal tree-
   Fodder tree-
   Boundary tree-

7. Uses of tree and tree-products:
   a) Consumption
   b) Sale
   c) Processed food

8. What do you think about the environmental services of tree?

   - Wind break
   - Soil erosion control
   - Nutrient cycling
   - Humidity and shade
   - Source of water
   - Air purification

Do you use trees in selling purpose?

9. What are the uses of planting trees?

   Please give the example of the tree species you planted and their uses…….

10. Have you planted trees along road side?

    -What is the importance of your road side plantation?
    - Please name the tree species you planted……..

11. Types and number of animals rearing:
    a) Cow…… Number: …….
    b) Goat…… Number: ……..
    c) Sheep…….. Number: ……
    d) Poultry……. Number: ……

12. Farm size and use of Livestock:

Animals	Draught	Meat	Milk	Egg	Fuel	Sale	Others
Cow							
Goat							
Poultry							
Others							

13. A) Sources of livestock feed used by farmers for their livestock-
    i) Grown on own field-
    ii) Bye from market-

    B) Relationship between farmers land size and types of fodder offered to livestock-

    i) Use of raw grass- ……..
    ii) Use of tree leaves- ……

    iii) Use of rice bran- ……

    iv) Use of oil cake- ……..

14. Methods of storage system:
    - Compilation of paddy straw: …….
    - Silage: ……

15. Tree-crop interaction:

Positive interaction	Negative interaction
Nutrient that taken up in the top soil by tree root can easily uptake by crop	Shading by the trees, reducing light intensity at the crop level
Litter/mulch decomposes and make nutrients available for tree and crop	Root competition between tree and crop for space
Optimum utilization of water, fertilizer etc.	Tree and crop can be host of each other for pest and diseases

16. Tree-livestock interaction:

Positive interaction	Negative interaction
Toxic compound can be extracted and used for pest control	Toxic components within, tree fodder can adversely affect livestock production
Livestock frequently take advantage of the shade provided in wooded sites	Many species contain secondary compounds that reduce the feed value
Tree leaves are provided as livestock fodder	Digestibility can be low and the leaves may contain toxins

17. Tree-environment interaction:

Positive interaction	Negative interaction
Tree produce oxygen that keeps environment livable	Adverse environment reduce production of tree
Trees reduce temperature	Tree production required inorganic fertilizer that pollute soil and water
Trees save soil from erosion	Sometimes pollen and small seed from tree cause air pollution

18. Crop-environment interaction:

Positive interaction	Negative interaction
Crop residues mixed with soil and increases soil fertility	Crop production required tillage that influence soil erosion by rain
Fertile soil required less inorganic fertilizer	Inorganic fertilizer polluted soil and water
Soil covered with crop reduces soil from washing away	Submerged crop produce methane gas

19. Livestock-environment interaction:

Positive interaction	Negative interaction
Land saving due to recycling of agricultural by-products as animal feed	Emission of greenhouse gases to the environment
Use of dung- cake as domestic fuel	Overgrazing and deforestation
Saving of chemical fertilizers due to use of dung as manure	Water pollution

20. What are the environmental factors that effect tree-crop-livestock production?

a) Flood and its effect…….
b) Storm and its effect…….
c) Drought and its effect……..
d) River bank erosion and its effect…….
e) High temperature and its effect……

21. Types of feed supplied at the time of natural hazards

i) Stacked paddy straw: …….
ii) Mustard oil cake: …….
iii) Rice bran: …….
iv) Tree leaves: ……
v) Fodder grown on homestead: ……
vi) Others: ……

22. Does the environmental condition conducive to farming:
……..

23. Farmers' problem associated with Tree, crop and livestock:

Problems on tree production	**Problems on crop production**	**Problems on livestock & poultry production**
Lack of good quality plant seed:	Lack of good quality crop seed:	Lack of proper treatment of livestock and poultry:
Irregular supply of high price fertilizer:	Irregular supply of high price fertilizer:	High price of veterinary medicine:
Lack of irrigation facilities:	Lack of irrigation facilities:	Balanced feed cost is high:
Problems of livestock grazing on plant field:	Problems of livestock grazing on crop field:	Lack of supply of livestock support service:
Lack of training facilities:	Lack of training facilities:	Lack of training facilities:
Lack of credit facilities:	Lack of credit facilities:	Lack of credit facilities:

24. Farmer' suggestion:

For Crop and Tree	**For livestock and Poultry**
Regular supply of good quality seed	Proper treatment of livestock & poultry
Increase irrigation facilities	Facilities of low cost medicine
Supply of low cost fertilizer	Ensure of balanced low cost feed
Training facilities on crop & Tree production	Training facilities on livestock & poultry production
Interest free Credit	Interest free Credit

25. Would you mind telling what factors motivated you to adopt mixed farming?
    - Sufficient food…….
    - Getting income…….
    - Helps in life risk reduction……

Signature of the researcher

Signature of the respondent

Thank you for your cooperation