AGROECONOMIC PERFORMANCE OF JACKFRUIT BASED AGROFORESTRY SYSTEMS AND VALUE-ADDED PRODUCT OF JACKFRUIT IN NETROKONA DISTRICT

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CERTIFICATE

This is to certify that the thesis entitled ***"AGROECONOMIC PERFORMANCE OF JACKFRUIT BASED AGROFORESTRY SYSTEMS AND VALUE-ADDED PRODUCT OF JACKFRUIT IN NETROKONA DISTRICT"*** *submitted to the faculty of Agriculture, Sher-e-Bangla Agricultural University (SAU), Dhaka, in partial fulfillment of the requirements for the degree of* ***Master of Science (MS)*** *in* ***Agroforestry and Environmental Science*** *, embodies the result of a piece of bonafide research work carried out by* ***Faria Jannat Ruma,*** *Registration number:* ***14-05830,*** *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 duly been acknowledged.

Dated: JUNE, 2021
Dhaka, Bangladesh

Dr. Nazmun Naher
Professor
Supervisor

Dedicated To
My
Beloved Parents

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ABSTRACT

The present study was carried out at three unions of Netrokona Sadar to identify the different types of jackfruit-based Agroforestry systems, the value-added products of jackfruit and the problems faced by the respondents. A simple random sampling technique was adopted to collect the necessary information through a structured questionnaire from 60 respondents during January to December 2020. Based on crop condition, a total of 4 jackfruit-based agroforestry systems were identified and the highest net return (74800 Tk. / ha) and BCR 2.01 was obtained from the Jackfruit-Rice based Agroforestry system. The discounted benefit cost ratio (1.26) and the internal rate of return (41.91%) clearly indicated that Jackfruit-based agroforestry system was productive and profitable for this region. About 60% respondents have no knowledge about value added product of Jackfruit, 56% respondents identified traditional methods of processing and 56% respondents identified no standard post-harvest handling practices as problem of value addition in jackfruit. Most of the farmers (65%) identified high price of inputs and 63.33% respondents identified inadequate storage facilities as problems faced by them. Therefore, a standard post-harvest handling practices and value addition is needed for improving economic potentiality of jackfruit.

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ABBREVIATIONS

BBS	=	Bangladesh Bureau of Statistics
BCR	=	Benefit Cost Ratio
CF	=	Cash Flow
CV	=	Cultivar
cm	=	Centimeter
DBCR	=	Discounted Benefit Cost Ratio
DR	=	Discounted Ratio
et. al.	=	et allii (and others)
g	=	Gram
MP	=	Murate of Potash
NPV	=	Net Present Value
PV	=	Present Value
TSP	=	Triple Super Phosphate
SD	=	Standard Deviation
HYV	=	High Yielding Variety
ha	=	Hectare
IRR	=	Internal Rate of Return
Kg	=	Kilogram
Km	=	Kilometer
m	=	Meter
%	=	Percent

CHAPTER I

INTRODUCTION

Bangladesh has increased national capacity for securing food access of large population. Though the grain food production increased, food in terms of balanced diet and nutrition security remain under challenge due to insufficient vegetable and fruit production against huge demand. The country has only 7.76 million ha of arable land and per capita arable land availability decreasing at an alarming rate, from 0.174 ha in 1961 to 0.048 ha in 2016 (World Bank, 2020). The soil fertility of arable land is decreasing day by day due to intensive cropping with improper management. Under these scenarios, it is necessary to develop alternate systems that could increase crop production and land use efficiency wherever possible. Because of increasing demand for food, fruits, timber, fodder, fuel wood, and poles, production of multiple products from the same land management unit are indispensable. Bangladesh has poor forest resources which is decreasing day-by-day due to several reasons. Furthermore, the land hungry agricultural sector is converting forest land to agricultural uses to feed the burgeoning population of Bangladesh. Due to this deforestation, serious imbalances have already been created in the eco-systems. Multiple productions from homesteads and croplands are indispensable for a country like Bangladesh where the population growth rate is very high and faster than its agricultural growth rate. The country cannot produce enough food to meet up the ever-increasing demand for over population, i.e., cereals, vegetables, fish, meat, milk and egg due to lack of modem techniques, inputs and available land. Agroforestry system having multipurpose tree plantation increased soil fertility, supplied fuel wood, generated work and improved socioeconomic condition of the farmers (Alam *et al.,* 2004). Farmer also gets their basic need such as food, fodder, fuel wood and timber from the same piece of land by practicing different Agroforestry system. As Agroforestry provides multiple products including fruits, vegetables, nutrition, fuel wood, fodder etc. to the households, it could be a good option to overcome the aforementioned situation.

Agroforestry as a new applied science is a matter of discussion in the contemporary time with the increase of human being in the geometrical progression while the land area

remaining infinite, there is no other alternative but to grow food, fuel, fodder and fiber in an integrated manner in the same unit of land. In Bangladesh, rice is cultivated in 82% (BBS,2020) of the total agricultural land. Farmers never allow plant tree in rice field because of their misbelieveness that shade is harmful for rice. But farmers must take the newly applied Agroforestry technology if the trees possess qualities like less shaded, hard pruning tolerable, less dispersing, deep rooted and less competable to nutrient, water and sunlight in the boundary. The Agroforestry practice increases yield and services per unit area. Assuming sustainability of the area more yield is expected from the different combinations. If there will be failure in one crop due to natural disasters, the other crop would supplement the deficit. Services like soil protection, amelioration of the micro-climate, colorful scenery, shelter belts etc. also can be obtained by this technology. Moreover, such cropping systems are highly productive and sustainable that provides the opportunity for year-round production. Worldwide, fruit tree-based Agroforestry systems are highly popular among resource limited producers (Bellow, 2004) and are capable in providing higher economic return even under stressed growing conditions prevailing under the upland situations than the other annual crops (Bikash *et al*., 2008).

Jackfruit based Agroforestry systems are widely found in Bangladesh with various vegetable and spice crops. Though most of the jackfruit trees are not planted in a systematic manner, there is enough space to grow suitable understory crops and reported to increase the overall production (Miah *et al*., 2018). The most common species in the Agroforestry system were jackfruit, mango, coconut, guava, and betel nut. But we are not aware of any previous study that has found Jackfruit to be as important as was found in the recent study. The jackfruit tree is well-adopted to tropical lowlands, and its fruit is the largest tree-borne fruit. A mature jackfruit tree can provide about 100 to 200 fruits in a year. The golden yellow timber with good grain is used for making furniture and building house construction in Bangladesh. This timber is termite-proof and is excellent to teak for building furniture. Wood of jackfruit is widely used in the manufacture of furniture, doors and windows, and roof construction. In addition to being more productive, the trees require relatively little care and thus provide farmers with huge opportunities to have spare time to do other working like economic and social activities. Like other district, Netrokona district is a populated area and its population increases rapidly day by day. As a result, the land for

cultivation of Agricultural crops is decreasing. On the other hand, the environment and soil are very suitable for jackfruit production. So, cultivation of crops with jackfruit can effectively utilize the underground space as well as it can increase the production of the land for the increasing population. It also utilizes the light, water and nutrients use efficiency which are otherwise will be wasted. It improves social and economic value of the locality. It also improves food and nutrition which are essential for healthy and peaceful life for the village people.

Jackfruit is rich in several nutrients. It can act as source of complete nutrition to the consumers. The fruit is equivalent to Avocado and olive in terms of the healthier mix of nutrients for human dietary needs, almost having the exact nutrient equivalents of mother's milk. It is rich in vitamin B and C, potassium, calcium, iron, proteins and high level of carbohydrates, affordable and readily available supplement to our staple food. Its seeds are rich in proteins and can be relished as a nutritious nut.

Value addition to agricultural products is the process of increasing the economic value and consumer appeal of an agricultural commodity. Various value-adding technologies such as processing and preservation, dehydration and drying, freezing technology, packing, labeling, etc. can be applied to agricultural produce to increase its value. Jackfruit has got great potential for value addition. More than 100 items can be prepared from jackfruit right from immature stage to well ripened stage. Each item has its own virtues in terms of taste, preference, keeping quality etc.

The importance of the fruit, seed and rind is known very little to the growers and consumers. Absence of organized marketing strategies among the growers' results in wastage of major quantity of the jackfruit produced. Value addition is important to utilize the surplus fruits available during the season as well to improve the livelihood of the farmers by producing value added products. Value addition is the process if changing or transforming a product from its original state to a more valuable state.

Jackfruit production can be increased by increasing the efficiency of Jackfruit growers using existing technology. Therefore, this study attempts to fulfill the following objectives.

Objectives

I. To identify the different types of jackfruit based Agroforestry systems at the study area
II. To determine the economic potentiality of different crops practiced with jackfruit based Agroforestry system and problem faced by the farmers and
III. To identify the use and value-added products from jackfruit at different stages

CHAPTER II

REVIEW OF LITERATURE

Review of some research work relevant to the present studies, which have been conducted in the recent past, are discussed below:

2.1 Agroforestry system

Agroforestry has been marketed as a long-term, environmentally friendly solution to managing upland environments. It entails combining annual and perennial food crops, as well as animals, for social, economic, and environmental benefits (Leakey, 1996).

Agroforestry systems have been the subject of a number of studies to determine their financial viability. Many of these studies looked at the financial costs of developing, operating, and producing various agricultural and wood crop combinations, as well as the possible gross revenues and profitability (Grado and Husak, 2004). Agroforestry systems have shown to be a financially feasible and appealing land use choice in a variety of situations around the world (Garrett 1994, as cited in Grado and Husak, 2004). Greater financial benefits from agroforestry might be attributed to increased biophysical productivity or lower input costs (Franzel, 2004).

Agroforestry is used in backyard gardens (Millat-e-Mustafa, 1997), crops (Roy, 1996), and forestlands, among other places. However, in Bangladesh, the long-term viability of these methods is a big worry. Agroforestry is seen as a cost-effective and long-term land use alternative, particularly for farmers with limited resources (Stocking *et al.*, 1990).

According to Nair (1990), agroforestry is not a new business because it has been performed for at least a century under various conditions and in various locales. The taunya system, which originated with Burmese (Myanmar) hill-farming expertise utilizing teak as the forest crop and was later implemented in Bangladesh at Kaptai in Chittagong district in the early 1870s, is the most common and extremely ancient Agroforestry technique.

According to Haque (1996), if afforestation is done effectively and comprehensively, at least 20% of the country's total land area outside of forest covers may be placed under

tree cover. The people of Bangladesh will benefit from agroforestry by having more food, more timber, and a healthier environment to live in.

Ahmed *et al*. (2008) in a study discovered potential plant species for both homestead and farming in the area, including mango (*Mangifera indica*), Palmyra palm (*Borassus flabellifer*), Babla (*Acacia nilotica*), Eucalyptus (*Eucalyptus camaldulensis*), ipil-ipil (*Leucaena leucocephala*), and Silkoroi (*Albizia procera*). To provide fuelwood, the trees on the homestead can be tended on a 2–3-year rotation. Fruit trees can be kept for a longer time to produce fruit and timber.

According to Miah *et al*. (2001), the main focus in Bangladesh should be on the planting of suitable agroforestry tree species into agriculture fields. However, before embarking on any form of tree-planting strategy on a crop field, it is critical to gain a thorough understanding of the existing primary agroforestry systems in the area.

Pathways, river courses, farm boundaries, and internal borders were all used to plant appropriate trees and plants in the densely settled agricultural community in Kenya's sub-humid mid-lands (Rocheleau and Hock, 1997). These hedgerows may provide 50% of the fire wood and 40% of the feed requirements of the area's families, with very little competition from existing agricultural land uses.

According to Jackson (1997), agroforestry systems that include a variety of tree and crop species provide significantly more potential for effective light interception and distribution management than monoculture forests and agricultural crops. When considering the waste nutrient resources experienced in orchards and tree crop combinations, the potential benefits of integrating field crops with trees are clear.

Linda (2020) had done an economic assessment of different Lotkon based agroforestry systems in Shibpur upazila of Narsingdi district. To explore economic potentiality, she observed 15 years of Lotkon cultivation where BCR was 2.46. Among 10 different Lotkon based agroforestry system, Lotkon-Jackfruit based system had the highest BCR (3.35) though most of the farmers (46.25%) used coriander as associated crop with Lotkon. From intertemporal budgeting, discounted benefit cost ratio (1.90), and internal rate of return (52.23%%) clearly indicated that Lotkon based agroforestry system was productive and profitable agroforestry system than sole Lotkon cultivation.

Halder (2020) identified six types of date-palm based agroforestry system practiced in Rajoir upazila of Madaripur district whereas by practicing this agroforestry system in 76.85 percent of total cultivated land, farmers earn major portion (77.21%) of their cash income. Highest net return (78170 Tk./ha) was earned and highest BCR (1.97) was from date-palm-jute and date-palm-mustard based agroforestry system respectively.

According to Lagemann (2003), the cropland Agroforestry system is critical to Bangladesh's economy. Agroforestry, in fact, is a term that invariably brings homesteads to mind, especially in a country like Bangladesh.

According to Hossain and Shailo (1987), the country's current annual demand for fuelwood is 2.04 million m^3 and for timber is 0.92 million m^3, respectively, while supply is now 0.61 million m^3 and 0.76 million m^3, resulting in a 1.42 million m3 fuel wood and 0.16 million m^3 timber deficit. The use of an agroforestry system may be able to compensate for this shortfall.

According to Abedin and Quddus (1990), the potential of agroforestry for environmental improvement and in sustaining increased output of food and forest produce must be exploited through the successful introduction of fast-growing exotic tree species and increased awareness of the multipurpose use of indigenous tree species.

2.2 Jackfruit based Agroforestry system and Importance of Jackfruit

Rahman (2015) carried out a study on farmers problems and prospects of jackfruit commercialization in Bhaluka upazila of Mymensingh district. By using Problem and Prospects Appearance Index (PPAI) his study result revealed that three fourth (67.4%) portion of the farmers experienced moderate problem and majority (79.1%) of them perceived medium level prospects of jackfruit commercialization. Several variables like annual family income from jackfruit, experience, knowledge on jackfruit cultivation, diversified use, selling demand, price of jackfruit at different marketing system showed significant negative relationship with the problems faced by the farmers whereas along with nutritional importance of jackfruit all of these variables posed significant positive relationship with the prospects of jackfruit commercialization.

To better understand the current Agroforestry condition, Akter *et al*. (2008) performed a survey in the farming system research site, Bagher Para, Jessore. Date palm, Babla, Palmyra palm, and Jackfruit were identified to be grown on the croplands for fruit, fuel,

timber, juice, molasses, and building materials, among other things. The key causes for date palm cultivation have been identified as the production of molasses, the usage of fuel, and the production of mats. It was discovered that income from date palms can feed a family for 5-6 months per year among marginal and small farmers.

According to Majumder (2011), low jackfruit prices have caused challenges for local farmers in eight upazilas in Khagrachhari's hilly area, where big yields were expected. In his report, he described how a farmer named Abul Kashem from Taindong village in Matiranga upazilla lost Tk. 800 after selling 4,000 jackfruits for only Tk. 25,000. In this case, he blamed a bad transpiration infrastructure, cheaper prices, and a lack of government market regulation.

Ahmmed (2010) conducted a study on jackfruit nutritional quality and postharvest loss evaluation. The study found that the postharvest problem of jackfruit was 16.13 percent, 11.40 percent, 9.22 percent, and 6.76 percent at the 'growers', 'Bepari', 'wholesalers', and ‘retailers' levels, respectively, and that the total postharvest loss of jackfruit in the entire supply chain was estimated to be 43.51 percent. The losses were primarily caused by faulty storage, irresponsible handling, and the old marketing delivery system.

Hossain *et al*. (1979) found that the jackfruit is rich in carotene and carbohydrates and moderately rich in ascorbic acid. It also contains some minerals like calcium and potassium and Vitamin B like thiamin, riboflavin and niacin. The large sized seeds are boiled or roasted and eaten as such or made into cooked vegetable. The seeds are reported to be more nutritious than the bulb, being richer in protein, fat, potassium and carbohydrate with considerable amount of phosphorus and calcium.

According to Khandaker *et al*. (2009), proper marketing infrastructure is critical for effective fruit marketing. Appropriate transportation and product handling are also critical for agricultural product trade, as well as ensuring fair prices and poverty reduction

In the research, Devi *et al.* (2014) discovered that Jack fruit is rich in several nutrients. It can act as source of complete nutrition to the consumers. . It is rich in vitamin B and C, potassium, calcium, iron, proteins and high level of carbohydrates.

Table 1. Nutritional value of jackfruit

Constituent	Average value
Moisture (%)	76.2
Energy (cal)	88.0
Protein (g)	1.9
Fat (g)	0.10
Fibre (g)	1.1o
Carbohydrates (g)	19.8
Potassium (mg)	107.0
Calcium (mg)	20.0
Phosporus (mg)	41.0
Iron (mg)	.56
β Carotene (mg)	175.0
Thiamine (mg	.03
Riboflavin (mg)	.13
Niacin (mg)	.40
Vitamin C (mg)	7.0

The ripe jackfruit presents a plenty amount of fermentable sugar, which may be exploited for the commercial production of vinegar and wine. Amit and Ambarish (2010) reported that the maximum alcohol content in jackwine was 10% (v/v), with a sugar utilization of 14% of total sugar solids. These results showed promise for the use of this fruit for commercial wine production. A certain maturity level and ripeness of jackfruit (29 to 30 °Brix) are essential for the production of jackfruit wine. Dehydrated jackfruit is a nutritious snack item when made from ripe jackfruit. Jackfruit is golden-yellow to orange and has a chewy texture with a sweet and sour taste (Diamante, 2009). Jackfruit is also used for chips. The starch and dry matter content of the raw material determines the yield of the processed product. Flake thickness, bulb length, total sugar solids, and reducing sugars were found to be important for increasing the yield and quality of jackfruit chips (Jagadeesh *et al*, 2006).

The protein and carbohydrate elements of prepared biscuits decreased with higher replacement of jackfruit seed flour. But moisture, fat, crude fiber and ash content

increased with higher replacement of jackfruit seed flour. The sensory parameter presented that up to 20% level incorporation biscuits were not significantly different with 0% jackfruit seed flour. But higher level of jackfruit seed flour biscuit rejected by the panellist as it was dark in color and hard texture (Islam, 2015).

Jackfruit seed flour presenting the highest essential amino acid composition followed by jackfruit seed which is germinated and raw jackfruit seeds. Leucine, the amino acid was the most abundant amino acid in jackfruit seed flour, while lysine and phenylalanine were the highest compositions found in germinated jackfruit seed flour. The jackfruit seed flour had the highest protein content (24.94%) while germinated jackfruit seed flour had the highest vitamin C content (78.78 mg/100 g). The flour element of three different treatments showed that the starch content was highest in germinated jackfruit seed flour while jackfruit seed flour contains vitamin C and also present significant amount of protein and dietary fibre (Zuwariah, 2018).

According to Hassan *et al.* (2011), post-harvest loss of 13 selected fruits and vegetables in main growing areas costs the country roughly Tk 3,442 crore in retail price per year. The post-harvest loss of fruits and vegetables such as jackfruit, pineapple, papaya, mango, litchi, banana, orange, cucumber, cauliflower, tomato, okra, brinjal, and red amaranth ranged from 23.6 to 43.5 percent, according to the findings. Post-harvest issues were detected in jackfruit at a rate of 44 percent, with the primary illnesses syndromes of shoot and fruit borer, stem-bleeding, and died back posing a serious danger in the leading jackfruit producing districts of Mymensingh and Gazipur. The loss is attributed to the fact that jackfruit is severely damaged by fruit borer (insects) and soft rot, and that growers in the investigated region, Mymensingh and Gazipur, rarely use pesticides or fungicides in the field to reduce damages. The over use of ripening chemicals, which speed fruit ripening and severely limit shelf life, is the second major cause of jackfruit loss.

According to Haque (2006), 30-34 percent of jackfruit has post-harvest difficulties.

2.3 Value addition of Jackfruit

According to Sharma *et al*. (2014) Value addition is the process if changing or transforming a product from its original state to a more valuable state. They found that Value addition is the process of changing or transforming a product from its original state to a more valuable state. Value addition to agricultural products is the process of increasing the economic value and consumer appeal of an agricultural commodity. Various value-adding technologies such as processing and preservation techniques, dehydration and drying technology, freezing technology, packing, labeling, etc. can be applied to agricultural produce to increase its value.Devi *et al*. (2014) discovered that Jackfruit has got great potential for value addition. More than 100 items can be prepared from jack fruit right from immature stage to well ripened stage. Each item has its own virtues in terms of taste, preference, keeping quality etc. A glimpse of the potentiality of the fruit for processing and value addition is as follows:

Table 2. Potentiality of jackfruit for value addition

Sl. No.	Stage of fruit	Items that can be prepared	Remarks	Type suitable
1	Immature	Culinary preparations	Fresh consumption	Both firm and soft
		Cutlets	Fresh consumption	Both firm and soft
2	Half mature	Pickle	Can be preserved	Both firm and soft
		Cutlets	Fresh consumption	Both firm and soft
		Pulao/ Biryani	Fresh consumption	Both firm and soft
3	Fully mature	Papad	Can be preserved	Firm type preferred
		cutlets	Fresh consumption	Both firm and soft
		chips	Can be preserved	Both firm and soft
		pakora	Fresh consumption	Both firm and soft
4	Well Ripened	Pulp (Base material)	Can be preserved	Both firm and soft
		Halwa	Can be preserved	Both firm and soft
		Gulab Jamun	Fresh consumption	Both firm and soft

		Sweet vada	Fresh consumption	Both firm and soft
		Miniappam (Unniappam	Fresh consumption	Both firm and soft
		Leather	Can be preserved	Both firm and soft
		Jam	Can be preserved	Both firm and soft
		Custard	Fresh consumption	Both firm and soft
		Wine	Can be preserved	Both firm and soft
		Squash	Can be preserved	Both firm and soft
		Kheer/Payasam	Fresh consumption	Both firm and soft
		Mocktail	Fresh consumption	Both firm and soft
		Cake	Fresh consumption	Both firm and soft
5	Seeds	Culinary preparations	Fresh consumption	Both firm and soft
		Pakora	Fresh consumption	Both firm and soft
		Kheer/Payasam	Fresh consumption	Both firm and soft
		Starch flour	Can be preserved	Both firm and soft

The value-added products from unripe, half ripe and ripe jackfruit and seed are presented in Table 3.

Table 3. Value added products of jackfruit

Stage of fruit	Value added products
Unripe fruit	Pickle, Chips, Brined Jackfruit, RTC Jackfruit, Dehydrated Jackfruit, Culinary preparations, Cutlets, Biryani
Half ripe fruit	Candy, Preserve
Fully ripe fruit	Jam, Leather, Rind Jelly, Squash, Nectar, Canned Bulbs, RTE (Ready-to-eat) Bulbs, RTS (Ready-to-serve) Drinks, Chutney, Toffee, Wine, Halwa, Kheer, Gulab Jamun, Ice-cream, Custard, Cake, Freeze dried pulp
Seeds	Seed powder, Starch flour, culinary preparation, Pakora, Kheer

Jackfruit seed was transferred into flour and used as a protein and carbohydrate supplement in diets. Also used as an element in foods in bakery product. The jackfruit seeds were dried and milled into flour. The flour has good binding ability to water. The seed flour was effectively used in some food. In the research work the biscuit with 20% concentration of jackfruit seed flour with different particle size was prepared. The particle size of jackfruit seed flour was taken 0.69mm. 0.73 mm, 0.77 mm and 0.82 mm. The overall acceptability of biscuits and cake with jackfruit seed flour particle size 0.77mm and 0.72mm respectively (Barge, 2019).

Jackfruit seeds that had been subjected to a combination of soaking, boiling, and fermentation. Five diets were formulated with the cooked Jackfruit seed meal representing 0, 8, 16, 24, and 32% of the diet. Cooking reduced tannins and oxalates in raw jackfruit seeds by over 80%. Soaking-boiling-fermentation treatment does not present a effective method to improve the nutritional value of Jackfruit seeds for broiler chickens (Ndyomugyenyi, 2016).

The fruit pulp can be used to make jam. The addition of a synthetic flavouring agent such as ethyl or n-butyl ester of 4-hydroxybutyric acid at 100 and 120 ppm, respectively, will greatly improve the taste of the jackfruit products (Technical Manual for Small-Scale Fruit Processors, 2004).

According to Patil (2008) explained, 'Higher the value addition better the pH management and lower will be losses. He also mentioned some causes for losses such as handling of raw produce through many stages of middlemen, processing is mostly controlled by urban rather than rural entrepreneurs which leads to losses in valuable by products, non-availability of adequate and efficient equipment and machinery etc. to be used in catchment areas, low level of entrepreneurial urge in rural areas due to constraints of finance, assured market and proper training on technology and on the whole, there exists a fragmented and inefficient value chain.

An official report from the BAS stated that jackfruit production continued to slow down by three percent annually since 2003 and recorded a 13.14 percent drop from the period of January to September 2009. In this Crop Statistics report from the period of 2003-2008, BAS explained that the country produced 884 thousand mt of jackfruit in 2008, 14 percent lower than the 1,024 thousand mt in 2007. Report result is the adverse effects

of typhoon Frank, rains during flowering stage, less flower induction, toppling down of trees due to typhoon Cosme, and the attack of anthracnose (Mojica, 2010).

Now-a-days people are more concerned about their health. In view snack ball was prepared using varied concentrations of jackfruit seed flour and in three different formulations study also quantifies changes in thiobarbituric acid, free fatty acid, total phenolic content and antioxidant activity of snack bar packed in polypropylene and metalized polyester films and stored under room temperature conditions for 28 days of storage study. At the time of storage, at room temperature thiobarbituric acid and free fatty acid content were increased while full phenolic content and antioxidant activity were decreased with increase in temperature and progression of storage period. Maximum retention of phytochemicals was seen in the snack ball packed in polypropylene as compared to metalized polyester films and stored at room temperature conditions study indicates potential application of jackfruit seed flour for preparation of low-cost nutritious value-added product (Meethal, 2017).

Bhuyan *et al*. (2013) reported that if the mature green jackfruits washed with clean water, peeled and cut into small pieces, kept in 8 per cent salt, 1.25 per cent acetic acid, 0.1 per cent KMS and 91.65 per cent water solution, the materials are poured into air tight plastic container and can store in cool and dry place.

CHAPTER III

MATERIALS AND METHODS

Proper methodology is the prerequisite of a good research. In scientific research the acceptability of the result depends to a great extent on the appropriate methodology. The researcher gave a careful consideration in following a scientific and logical methodology for carrying out this research. The design of the survey for the present study involved some necessary steps, which are presented in the following section:

3.1 General Description of The Study Area

Netrokona is situated in the northern part of Bangladesh, near the Meghalayan border. It is a part of the Surma-Meghna River System. Netrokona District (Mymensingh division) area 2747.91 km sq km, located in between 24°34' and 25°12' north latitudes and in between 90°00' and 91°07' east longitudes. It is bounded by the Meghalaya state of India on the north, Kishoreganj district on the south, Sunamganj district on the east and Mymensingh district on the west. Average literacy 34.9%; male 37.9%, female 31.9%. Main sources of income Agriculture 72.43%, non-agricultural labourer 3.40%, industry 0.53%, commerce 10%, transport and communication 2.11%, service 3.92%, construction 0.91%, religious service 0.26%, rent and remittance 0.23% and others 6.21%.

Netrakona Sadar is located at 24.8750°N 90.7333°E. It has 51039 households and total area 340.35 km2. Netrakona Sadar had a population of 372,785. Males constituted 50.17% of the population and females 49.83%. Netrakona Sadar had a literacy rate of 45.97% for the population 7 years and above. In Netrakona, the wet season is hot, oppressive, and mostly cloudy and the dry season is warm and mostly clear. Over the course of the year, the temperature typically varies from 56°F to 92°F and is rarely below 51°F or above 98°F.The cool season lasts for 1.6 months, from December 13 to February 2, with an average daily high temperature below 79°F. The coldest month of the year in Netrakona is January, with an average low of 56°F and high of 77°F.

3.2 Selection of The Study Area

Selection of the area is an important step for research study. The area in which a business survey has to be carried out depends on the purposes of the survey and possible cooperation from the farmers. The study was conducted in three unions under Netrokona sadar. Farmers of this area have long been practicing various Agroforestry practices, where Jackfruit is cultivated as main crops following silvi- agricultural practices. Farmers of this upazila grow Jackfruit in association with different kinds of field crops (Rice, Cucumber , Turmeric, Sweet gourd etc.).Selected three unions were Madanpur, Lakshmiganj, Dakshin Bishiura which were considered for data collection (Figure 1).

3.3 Selection of Samples and Sampling Technique

It is not possible to make a survey taking all farmers of the study area due to time and resources constraint.The normal practice therefore, is to select sample of practicing jackfruit based argoforestry. Purposive Simple random sampling technique was therefore used to select the respondents for the present study. For selection of sample, a list of the farmers in the selected Upazila was prepared with the help of extension officials of the Upazila. A total 60 farmers were selected randomly from the list for data collection. Thus sample composed of 60 farmers taking 20 farmers each from Madanpur, Lakshmiganj, Dakshin Bishiura.The respondents were categorized into small, medium and large on the basis of farm size. A detailed structured of population and sample has been presented in the Table 4.

Table 4. Distribution of population and sample of the selected unions

Upazila	Unions	Population	Sample	Reserved
Netrokona Sadar	Madanpur	110	20	5
	Lakshmiganj	80	20	5
	Dakshin Bishiura	90	20	5
Total		280	60	20

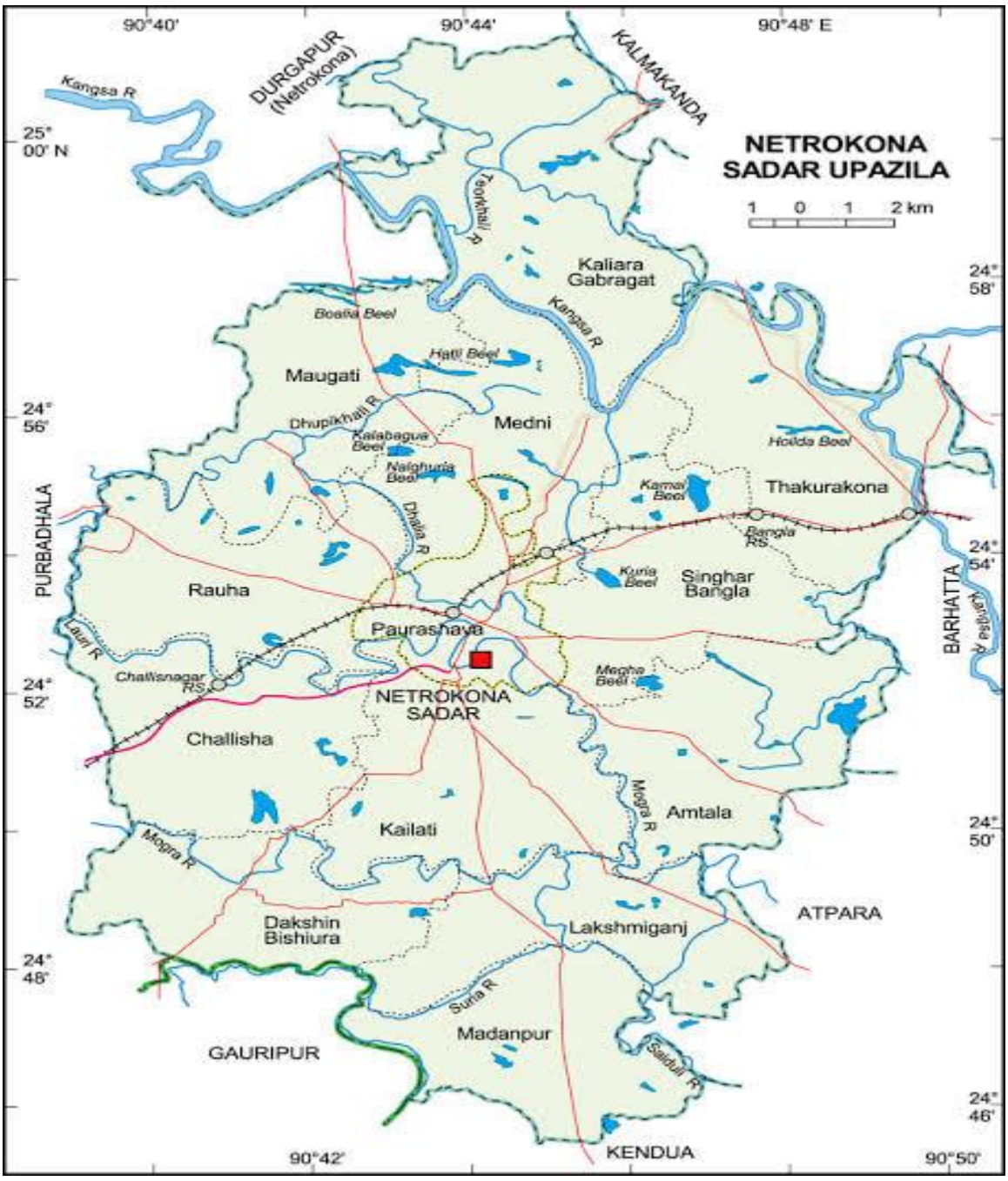

Figure 1. Map of Netrokona Sadar upazila showing study area

3.4 Preparation of Interview Schedule and Pre-testing

For collecting primary data through farm survey method, preparation of interview schedule is crucial need. A preliminary interview schedule was designed to collect the relevant information from the farmers in accordance with the objectives set for the study. In the farm business analysis interview schedule should be prepared very carefully and efficiently. Since a farm survey largely depends on the preparation of the survey questionnaire so before finalization the draft schedules, it was, therefore, pretested to avoid inconsistencies and to verify the relevance of questions and the nature of response of the farmers. The draft schedule was pre-tested with a few sample farmers of the study areas by the researcher himself. Thus, some parts of the draft schedule were improved, rearranged and modified in light of the actual and practical experiences gained from the pre-testing. The final schedule contained the following key items of information.

i. Identification of the sample farmers,
ii. Socio-economic characteristics,
iii. Information relating to quantities of input used, costs, returns, prices, wages etc. of Jackfriut production and
iv. Problems faced and suggestions made by the farmers.

3.5 Period of the Study

The study was conducted during the period from January, 2020 to December, 2020 through field testing of interview schedule, direct interviewing of the respondents, field visit and observations, and discussion with the concerned experienced farmers.

3.6 Collection of Data

The survey was conducted by the researcher herself. Data were collected from primary sources and it was accomplished by direct interviews with the farmers. Personal visits, rapport building with the farmers were performed to collect farm level information. The respondents were interviewed during their leisure time so that they could respond easily. During data collection, the aim and objectives of the study were clearly explained to the respondents. The researcher assured the farmers that all information would be kept confidential. It was also made clear to the respondent that the present data would mainly

be used for conducting research which was an academic exercise to fulfill partially her requirement for Master's Degree in Agricultural Forestry at Sher-e-Bangla Agricultural university. Thus, they were convinced and provided reasonably accurate information. Collection of accurate and reliable data and other necessary information from farmers was difficult task since the sample farmers did not keep written records on farm business transactions or activities. Hence, it was very difficult to collect actual data and the researcher had to rely completely on the memory of the sample farmers. To overcome, this problem all possible efforts were made by the researcher to ensure the collection of reasonably accurate information from the field on recall basis. After completion of each interview, the schedule was checked and verified to be sure that answers to each item had been recorded properly. If there were any items overlooked or obscure, the farmers were revisited to obtain missing and/or correct information. The interview schedule was designed to collect information in local units. However, these local units were converted into standard units before analyzing and presenting the data.

In addition to field level primary data, secondary data information having relevance with this study were also collected and discussed for research from different handouts, reports, published and unpublished documents of Government of Bangladesh (GoB) and its different organizations and agencies such as Statistical Yearbook of Bangladesh, Bangladesh Economic Review, various journals, newspaper, notifications, etc.

3.7 Data Analysis

After collection of data, these were coded, summarized and processed for analysis. These data were verified to eliminate possible errors and inconsistencies. The first step was taken to scrutinize the data of each and every schedule to find out any inconsistency or omission in the data collection and avoid irrelevant information. Processed data were transferred to a master sheet for statistical analysis using SPSS 16.0, computer software for analyzing Social the data. In order to achieve meaningful conclusions, tabular technique of analysis was intensively used because its simplicity.

3.7.1 Characteristics of the Respondents

(a) Age

Age of the respondents was measured in terms of actual years from their birth to the time of interview, which was found on the basis of verbal response of the rural people (Tinni, 2017). Age of the farmers were categorized into three groups as young (<40), middle (40-50) and old (>50).

(b) Education

Education was measured by assigning score against successful years of schooling by a respondent. Education of the farmers was categorized into five groups as illiterate (0), primary education (1 - 5), secondary education (6 -10), HSC education (11 - 12) and above HSC education (> 12).

(c) Family Size

The family size was measured by the total number of members in the family of a respondent. The family members included family head and other dependent members like husband/wife, brother and sister, parents, children etc. who lived and ate together. The total number of family members was considered as his family size score. Family size (number of family members) of the farmers was categorized into three groups as small family containing up to five members, medium family containing five to ten members and large family containing more than ten members.

(d) Farm Size

Farm size of a respondent was measured in terms of land area occupied by agricultural practice. Based on their farm size, the farmers were classified into three categories followed as Small, Medium and Large with the range of up to 1 ha , 1 to 2 ha, above 2 ha respectively.

(e) Occupation

Occupation of a respondent was measured in terms of working by him and respondent to the time of interview. It was operationally measured in terms of actual occupation. On the basis of their occupation they are classified as agriculture, business and service and others.

(f) Annual Income

Annual income of the farmers was categorized in three groups such as small, medium and large income.

3.7.2 Discounted Benefit Cost Ratio (DBCR)

Benefit-cost ratio is the ratio of discounted benefit divided by discounted cost. It implies the benefit derived from one unit of cost.

$$\text{Benefit-Cost Ratio (BCR)} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}}$$

Where, Bt = Gross benefit in ith year

Ct = Total cost in ith year

t = Number of years (1, 2, 3, ... n) , i = Interest rate

3.7.3 Net Present Value (NPV)

This is the present value of the cash flow stream. It can be computed by subtracting the total present value of cost from the total present value of benefit.

$$\text{Net present value (NPV)} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t}$$

3.7.4 Internal Rate of Return (IRR)

It is the discount rate, which just makes the net present value of cash flow equal to zero. It represents the highest possible rate of return from an investment over the project life. Internal rate of return is that discount rate 'i' such that,

$$\sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} = 0$$

The operating formula of calculating IRR is,

$$\text{IRR} = \text{Lower discount rate} + \text{Difference between the two discount rates} \left(\frac{\text{Present value of cash flow at lower discount rate}}{\text{Absolute difference between the present values of cash flow at the two discount rates}} \right)$$

3.8 Procedure for Computation of Cost and Return

To determine the profitability, it is necessary to compute all the cost items and deduct them from the gross value of outputs, which the farmer produces.

3.8.1 Estimation of Cost

The farmers practicing Jackfruit based agroforestry system had to incur costs for different inputs, which are used in the production process. The input items were valued at the prevailing market price and something government price. In calculating the production cost, the cost of various components like human labor, seedling, cow dung, fertilizer, irrigation, interest on operating capital, land use, etc. were considered.

(a) Cost of Human Labor

Human labor cost for different operations such as land preparation, sapling/seedling transplantation, application of fertilizer and irrigation, pruning, harvesting, marketing etc. were calculated by the actual wages (with/without meal). The farmers were paid for these

operations. The labor has been measured in a man-day unit, which usually, consisted of 8 hours in a day.

(b) Cost of Manures and Fertilizer

Farmers use different types of manures and fertilizers such as cow dung, urea, TSP, MP, oil cake etc. for growing Jackfruit and associated crops. Cost of fertilizer was estimated on the basis of actual market price.

(c) Cost of Irrigation, Drainage, Pruning/Thinning and Pesticide Application

Very few farmers used irrigation for their Jackfruit production and also used irrigation in the recent years. Costs of irrigation were estimated on the basis of electricity charge per day.

(d) Cost of Interest on Operating Capital

Interest on operating capital was calculated taking into account of nonmaterial inputs like human labor for land preparation, transplantation, application of fertilizer and pesticides, weeding, harvesting etc. and material inputs like seedlings, fertilizers etc. used in Jackfruit production. Hence, interest was charged as per prevailing bank rate of 12% per annum interest rate of opportunity capital for Jackfruit production. It was assumed that if the farmers would deposit the money in a bank, he would have received some interest at that rate. It was computed by using the following formula –

Interest of operating capital = Operating cost × Rate of interest × Time

(e) Land Use Cost

The cost of land use was estimated by the cash rental value of land. In calculating the land use cost, the average rental value of land per hectare for a particular year was used.

(f) Gross Cost, Gross Return, Net Return

Gross cost was calculated by adding all the costs of variable and fixed inputs.
Gross return was estimated by multiplying the total amount of product produced by their respective prevailing market price. Net return was obtained by deducting gross cost from gross return.

CHAPTER IV

RESULTS AND DISCUSSION

In this chapter the findings of the study and their interpretations are presented. This chapter deals with the individual characteristics of the participants, condition of jackfruit cultivation, cost of production of different jackfruit-based agroforestry systems and comparison of different jackfruit-based agroforestry systems. Obtained results, different suggestions and future plan from the selected respondents have been discussed by the following headings:

4.1 Characteristics of The Sample Farmer

4.1.1 Age

Age of the respondents is an important factor of involvement in any income generating activity. The distribution of sample farmers was classified into three age groups i.e. below 40 years, 40 to 50 years and above 50 years. Age of the respondents ranged from 26 to 65 years with mean value of 47.70.

Table 5. Distribution of the respondents according to their age group

Characteristics	Category (Age group)	Range		Mean	Frequency	Respondent (%)
		Minimum	Maximum			
Age (years)	<40	26	65	47.70	22	36.67
	40-50				28	46.67
	>50				10	16.66
Total					60	100

Table 5 shows that the lowest 16.66 percent farmers belong to the age group above 50 and the highest 46.67 percent belong to the age group 40 to 50 years and others 36.66 percent farmers belong to the age group below 40 years. Different result were observed

by Nasreen *et al*., (2013), Linda (2020) in different study area where young aged respondents group was higher than the middle and old aged respondents groups.

4.1.2 Education

Education plays a very important role in adopting improved practices in farming. Education makes a man more capable of efficiently managing scarce resources with a view to earn maximum profit. From educational point of view, all the sample farmers were grouped into five categories i.e., illiterate (0), primary (1-5), secondary (6-10), HSC education (11-12) and above HSC (>12).

Table 6. Distribution of respondents according to their education level

Characteristics	Category of Education level	Range		Mean	Frequency	Respondent %
		Minimum	Maximum			
Education	Illiterate (0)	0	16	6.4	14	23.33
	Primary (1-5)				21	35
	Secondary (6-10)				11	18.33
	HSC education (11-12)				9	15
	above HSC (>12).				5	8.34
Total					60	100

Table 6 showed that Education of the respondents ranged from 0 to 16 with mean value of 6.4. Among the respondents, 23.33 percent were illiterate, 18.33 percent secondary education and 15 percent had higher secondary education.

The results also showed that the maximum 35 percent farmers had primary education and only 8.34 percent farmers had above HSC level education which was the lowest in number among the respondents. It seems that due to lack of available support from family they were unable to continue their higher study. Similar result was observed by Reza (2007) where the highest number of respondents were educated up to secondary level education.

4.1.3 Family Size

In this study family size has been defined as total number of persons living together excluding servants and taking their meals unitedly from the same kitchen and living under the control of one head. Family size of the farmers was categorized into three groups i.e. small family (up to five members), medium family (five to ten members) and large family (above ten members). The family member of the respondents varied from 3 to 12 with an average of 7.

Table 7. Distribution of respondents according to their family size

Characteristics	Category	Range		Mean	Frequency	Respondent %
		Minimum	Maximum			
Family size (No. of people)	Small family (up to 5)	3	12	7	25	41.67
	Medium family (5-10)				28	46.67
	Large family (above 10)				7	11.66
Total					60	100

Table 7 showed that among the respondent's highest 46.67 percent belonged to the medium family, 11.66 percent belonged to the large family and 41.67 percent belonged to the small family.

4.1.4 Occupation

Various occupations were observed among the respondents. The main occupations of the respondent farmers are presented in Table 8. In the present investigation it was observed that there were four categories of occupation as agriculture, business, day labour and others.

Table 8. Distribution of respondents according to their occupation

Characteristics	Category	Frequency	Respondent (%)
Occupation	Agriculture	28	46.67
	Business	22	36.67
	Service	7	11.66
	Others	3	5
Total		60	100

Table 8 represents the occupational status of the farmers of the study area. It can be seen from the table that the lion share of small farmer is covered within the agricultural profession which cover 46.67 percent and business, labor and other profession covers 36.67percent, 11.66 percent and 5 present, respectively.

4.1.5 Annual income

The annual income of a respondent was determined by adding his income from (crop, vegetables, tree, cattle, poultry, fisheries, business, job, and other sources) during a year. Annual income of the farmers was categorized in three groups such as Low income (up to 50000 Tk), medium income (50500-150000 Tk) and large income (above 150000 Tk) which is shown in table 9.

Table 9. Distribution of respondents according to their annual income

Characteristics	Category	Range		Mean	Frequency	Respondent %
		Minimum	Maximum			
Annual income (000 tk.)	Low Income (Up to 50000)	28	400	210	15	25
	Medium Income (50500150000)				23	83.33
	High income (above 150000)				22	36.67
Total					60	100

The range of annual income was Tk.28000 to Tk 400000 with an average of Tk.210000. Among the farmers 83.33 percent had medium annual income,25 percent had low annual income and 36.67 percent had high annual income. Linda (2022) and Reza (2007) found the similar result where highest number of respondents were medium annul income.

4.1.6 Farm size

Farm size of the respondents was categorized in three groups such as small farmers (up to1 ha of land), medium farmers (1 to 2 ha) and large farmer (above 2 ha of land). Farm size of the respondents varied from 0.04 to 5 hectare (ha). The average farm size was 2.53 ha.

Table 10. Distribution of respondents according to their farm size

Characteristics	Category	Range		Mean	Frequency	Respondent %
		Minimum	Maximum			
Farm size (ha.)	Small farm (Up to 1ha)	0.04	5	2.53	17	28.34
	Medium farm (1 to 2 ha)				32	53.33
	Large farm (above 2 ha)				11	18.33
Total					60	100

Table 10 showed that among the respondents the highest 53.33 percent were medium farmers and large farmers and small farmers were 18.33 percent and 2834 percent, respectively. Similar result was observed Nasreen *et al.* (2013) where highest respondents were small farm sized

4.2 Types of Jackfruit-Based Agroforestry System Practiced in Selected Area

4.2.1 Farmer's Opinion on Jackfruit Based Agroforestry System

Farmer's opinion on jackfruit-based agroforestry system was categorized in two groups such as sole jackfruit and jackfruit-based agroforestry system (Table 11). Only (28.33%) respondent preferred sole jackfruit. On the other hand, most of the respondent preferred (71.66%) jackfruit-based agroforestry system.

Table 11. Farmer's opinion on jackfruit-based Agroforestry system

Type of production system	Respondents	
	Frequency	Percentage (%)
Sole jackfruit	17	28.33
jackfruit based Agroforestry system	43	71.66
Total	60	100

4.2.2 Existing jackfruit-based Agroforestry System

Diversification was found regarding existed jackfruit-based Agroforestry system at Netrokona. Farmers of the studied area were found to cultivate different vegetables in associated with jackfruit trees. Jackfruit trees are planted as boundary around field. Sometimes the farmer followed spacing and design and sometimes no design is followed. Most of the time Jackfruit tree is planted according to the farmer's desire (7-9 m distance). In many villages farmers are practicing different types of plantation. After an extensive survey of the selected areas of Netrakona, the following Jackfruit based Agroforestry practices were identified. From table 12, we can see that the most frequently jackfruit-based agroforestry systems were Jackfruit- rice based Agroforestry (65.00%), Jackfruit-Turmeric based Agroforestry (60%), Jackfruit-sweet gourd-based Agroforestry (47.25%), Jackfruit-Cucumber based Agroforestry (51.25%).

Table 12. Distribution of respondents according to jackfruit-based agroforestry system

Agroforestry system	Number of respondents	Percent respondents
Jackfruit- rice based Agroforestry	52	65%
Jackfruit-Turmeric based Agroforestry	48	60%
Jackfruit-Sweet gourd based Agroforestry	38	47.5%
Jackfruit-Cucumber based Agroforestry	41	51.25%

4.2.3 Duration of Jackfruit Based Agroforestry System Practiced

The experience of farmers with Jackfruit based agroforestry system was categorized in three groups i.e., below 10 years, 10 to 15 years and above 15 years.

Table 13. Distribution of respondents according to the time they are practicing Jackfruit cultivation

Time (years)	Range		Mean	Respondents	
	Minimum	Maximum		Frequency	Percentage (%)
Below 10	4	35	16.7	17	28.34
10 to 15				24	40
Above 15				19	31.66
Total				60	100

Among them the highest 40 percent farmers practiced Jackfruit farming for 10-15 year, 28.34 percent for less than 10 years and 31.66 percent farmers practiced Jackfruit cultivation for more than 15 years.

4.3 Contribution of Jackfruit-Based Agroforestry in The Study Area

4.3.1 Annual Income from Jackfruit-Based Agroforestry System

The respondents are categorized in three groups as low, medium and high (Table 14). Maximum (51.66%) of the farmers had medium income from Jackfruit based agroforestry system. 20% farmers had high income and the rest 28.33% farmers had low income.

Table 14. Distribution of farmers according to their annual income from jackfruit based agroforestry system

Categories	Respondents	
	Frequency	Percentage (%)
Low (<25000 Tk)	17	28.33
Medium (25000-75000tk)	31	51.66
High (>75000 Tk)	12	20
Total	60	100

4.3.2 Area of Land Having Jackfruit-Based Agroforestry System

On the basis of land having jackfruit-based Agroforestry system respondents were categorized into three groups as shown in Table 15.

Table 15. Distribution of respondents according to their area of land in which they have Jackfruit trees

Area of land (ha.)	**Respondents**	
	Frequency	**Percentage (%)**
Below 0.04	25	41.67
0.04 to 0.08	23	38.33
Above 0.08	12	20
Total	60	100

Data in table 15 show that the highest proportions 41.67 percent of the respondents had below 0.04 ha of land in which they have applied Jackfruit based Agroforestry system. 38.33 percent respondents had 0.04 to 0.08 ha where only 20 percent had above 0.08 ha of land in which they have applied Jackfruit based Agroforestry system.

4.3.3 Number of Jackfruit Trees Owned by Farmers

The farmers were categorized in three groups' shows in Table 16.

Table 16. Distribution of farmers according to the number of Jackfruit trees

Categories	Respondents	
	Frequency	Percentage (%)
Low number of trees (below 10)	7	11.67
Medium number of trees (10-20)	28	46.67
Large number of trees (above 20)	25	41.66
Total	60	100

Table 16 showed that about 46.67 percent farmers had 10 to 20 Jackfruit trees, 41.66 percent farmers had above 20 Jackfruit trees and the rest 11.67 percent had less than 10 trees.

4.4 Economic Performance of Jackfruit Based Agroforestry System

For estimation of economic performance, it is necessary to calculate different types of cost and return of the production. For jackfruit-based Agroforestry system year wise cost and return are shown in Table 17.

4.4.1 Cost of Jackfruit-Based Agroforestry System

Different types of costs have been presented in Table 17. The cost for seedling, and land preparation were Tk. 16000 and 5000 Tk/ha respectively. Other costs were fertilization, land use cost, operational cost, pesticide, harvesting and marketing. Among them land use cost was higher for the system. Table 17 showed that the total cost per hectare at

initial, 1st, 5th, 10th and 15th year for the jackfruit-based Agroforestry system were Tk. 24024,35608, 43096,62240,86800 respectively.

4.4.2 Benefit from jackfruit-based agroforestry system

After plantation of jackfruit trees, harvesting of fruit was started from third to fourth year. But in the initial year of fruiting, the number of fruits was very lower in quantity. So, in the first 3 years the net return was negative. From the 4th year it was gradually increased and higher production period of jackfruit was 10 to 12 years and it started to give more production at 15 years and up to 30-35 years. The highest gross and net return in the 15th year that was Tk.162400 and Tk 75600 respectively.

4.4.3 Inter-Temporal Budgeting for Jackfruit-Based Agroforestry System

Intertemporal budgeting for jackfruit-based Agroforestry system is presented in Table 18. For intertemporal budgeting all cost incurred and benefit accrued from the trees and vegetables have been taken into consideration.

Table 17. Year wise different cost and return per hectare (Tk./ha) of Jackfruit production of 15 years

Age of Jackfruit	Seedling Cost		Land Preparation					Interest on operating capital	Total cost	Gross Benefit	Net Return
Initial	16000		5000					15120	36120		
	Fertilizer cost	Fertilizer application cost	Pesticide cost	Inter. oper. cost	Harvesting cost	Marketing cost	Land use cost				
1	3000	400	200	1500	0	0	25000	5508	35608	0	-35608
2	3200	400	250	1700	0	0	25000	5994	36544	0	-36544
3	3600	500	300	2000	0	0	25000	6912	38312	28500	-9812
4	3600	500	300	2500	500	0	25000	7992	40392	42200	1808
5	4000	500	300	3000	500	400	25000	9396	43096	57000	13904
6	4000	800	400	3000	1000	800	25000	10800	45800	69500	23700
7	6000	1000	500	3000	1000	1000	30000	13500	56000	80500	24500
8	6000	1000	500	3500	1500	1200	30000	14796	58496	92300	33804
9	6000	1000	800	3500	1500	1200	30000	15120	59120	99350	40230
10	7000	1200	800	3500	1500	1500	30000	16740	62240	110340	48100
11	7000	1200	800	4000	2000	2000	35000	18360	70360	121000	50640
12	7000	1200	1000	4000	2000	2000	35000	18576	70776	135000	64224
13	9000	1500	1000	4500	3000	2000	40000	22680	83680	145500	61820
14	9000	1500	1000	4500	3000	3000	40000	23760	85760	157700	71940
15	9000	1500	1000	4500	3000	3500	40000	24300	86800	162400	75600
Total	87400	14200	9150	48700	20500	18600	460000	214434	909104	1301290	392186
BCR=1.43											

4.4.4 Cost

Jackfruit tree gave first fruit at the age of three. The economic life of jackfruit-based system is considered for 30-35 years. For 1st, 2nd, and 3rd year the production cost was Tk. 35608, 36544, 38312 respectively (Table 18). The production cost was increased with the increase of age of tree.

4.4.5 Benefit

In jackfruit-based agroforestry system the benefit was started from 4th year of plantation. From eight year of plantation, it was higher because at this stage jackfruit give maximum yield and it continued up to15 years of plantation.

4.4.6 Evaluation of Intertemporal Budget for Jackfruit-Based Agroforestry System

Intertemporal budget for Jackfruit based agroforestry system showed that the cash flow at the 1st, 2nd, and 3rd year were negative, but it became positive from the 4th year and continuing up to 15th year (Table 18). The discounted benefit cost ratio (1.26), net present value (Tk.105669.5) and internal rate of return (41.91%) clearly indicated that jackfruit-based agroforestry system was productive and economical agroforestry system. The discounted benefit cost ratio 1.26 indicated that if a farmer invests Tk. 100, he would get return of Tk. 126. Again, the difference between discounted gross benefit and discounted gross cost indicated that the net present value was Tk. 105669.5 (Table 18).

Table 18. Intertemporal budgeting (per ha) for jackfruit-based agroforestry for 15 years

Age of jackfruit tree	Gross Cost	Gross Benefit	CF (Net Return)	PV of Tk. 1 at 100% DR	Discounted CF at 100% DR	PV of Tk. 1 at 110% DR	Discounted CF at 110% DR	PV of Tk. 1 at 11% DR	Discounted Gross Cost	Discounted Gross Benefit	Net PV at 11% DR
1	35608	0	-35608	1	-35608	1	-35608	1	35608	0	-35608
2	36544	0	-36544	0.5	-18272	0.476	-17394.9	0.901	32926.14	0	-32926.1
3	38312	28500	-9812	0.25	-2453	0.227	-2227.32	0.812	31109.34	23142	-7967.34
4	40392	42200	1808	0.125	226	0.108	195.264	0.731	29526.55	30848.2	1321.648
5	43096	57000	13904	0.063	875.952	0.051	709.104	0.659	28400.26	37563	9162.736
6	45800	69500	23700	0.031	734.7	0.024	568.8	0.593	27159.4	41213.5	14054.1
7	56000	80500	24500	0.016	392	0.012	294	0.535	29960	43067.5	13107.5
8	58496	92300	33804	0.008	270.432	0.006	202.824	0.482	28195.07	44488.6	16293.53
9	59120	99350	40230	0.004	160.92	0.003	120.69	0.434	25658.08	43117.9	17459.82
10	62240	110340	48100	0.002	96.2	0.001	48.1	0.391	24335.84	43142.94	18807.1
11	70360	121000	50640	0.001	50.64	0.001	50.64	0.352	24766.72	42592	17825.28
12	70776	135000	64224	0	0	0	0	0.317	22435.99	42795	20359.01
13	83680	145500	61820	0	0	0	0	0.286	23932.48	41613	17680.52
14	85760	157700	71940	0	0	0	0	0.258	22126.08	40686.6	18560.52
15	86800	162400	75600	0	0	0	0	0.232	20137.6	37676.8	17539.2
Total					-53526.2		-53040.8		406277.6	511947	105669.5

(Discounted Benefit Cost Ratio) DBCR=1.26 and (Internal Rate of Return) IRR=41.91%

DR= Discounted Rate, CF= Cash Flow and PV= Present Value

4.5. Cost of production of Jackfruit Based Agroforestry System

4.5.1 Jackfruit- Rice Based Agroforestry System

In this system all the costs were estimated by the help of previous results and the help of respondent farmers. Here Table 19 showed that the total cost of production for Jackfruit was 5500 Tk/ha and the total cost of production for rice was 68250 Tk/ha.The selling price of Jackfruit was 29000 Tk/ha and selling price of rice was 119550 Tk/ha respectively. The BCR of Jackfruit- rice based Agroforestry system was 2.01 (Table 19) which is more than sole jackfruit cultivation BCR (1.43) therefore, proves that jackfruit-based Agroforestry system is beneficial than sole jackfruit cultivation.

Table 19. Cost of Production of Jackfruit- rice based Agroforestry system per hectare area

Items	**Material Cost (Tk.)**	
	Jackfruit	**Rice**
Planting material cost	800	2000
Fertilizer cost	1000	9000
Pesticide application cost		1300
Instrument cost	500	500
Items	**Non-material Cost (Tk.)**	
	Jackfruit	**Rice**
Land preparation cost		11000
Intercultural operation cost	500	5000
Labor cost	1000	10000
Harvesting cost	500	10700
Marketing cost	700	2000
Fixed cost	500	16750
Total cost	5500	68250
Grand total	**73750**	
Gross Return/Output:		
Items	**Jackfruit**	**Rice**
Sell price	27000	101950
Own consumption	2000	17600
Total income	**148550**	

Benefit Cost Ratio:

$$\textbf{Benefit Cost Ratio (BCR)} = \frac{\text{Gross Income}}{\text{Total Cost of Production}} = \frac{148550}{73750}$$

$$= 2.01$$

4.5.2 Jackfruit-Turmeric Based Agroforestry System

Table 20 showed that the total cost of production for Jackfruit in this system was 7600Tk/ha. and the total cost of production for turmeric was 49060 Tk/ha and the selling price of Jackfruit and turmeric was 22500 Tk/ha and 88500 Tk/ha respectively (Table 20). Here the BCR was 1.92 which is more than sole jackfruit cultivation BCR (1.43) therefore, proves that jackfruit-based Agroforestry system is beneficial than sole jackfruit cultivation.

Table 20. Cost of Production of Jackfruit- Turmeric based Agroforestry system per hectare area

Items	**Material Cost (Tk.)**	
	Jackfruit	**Turmeric**
Planting material cost	700	10000
Fertilizer cost	1500	4000
Irrigation application cost		800
Instrument cost	600	1000
Items	**Non-material Cost (Tk.)**	
	Jackfruit	**Turmeric**
Land preparation cost		5000
Intercultural operation cost	800	4000
Labor cost	1200	5000
Harvesting cost	1500	3000
Marketing cost	1200	1200
Fixed cost	800	15060
Total cost	7600	49060
Grand total	**57360**	
Gross Return/Output:		
Items	**Jackfruit**	**Turmeric**
Sell price	21500	87000
Own consumption	1000	1500
Total income	**110500**	

Benefit Cost Ratio:

$$\textbf{Benefit Cost Ratio (BCR)} = \frac{\text{Gross Income}}{\text{Total Cost of Production}} = \frac{110500}{57360}$$

$$= 1.92$$

4.5.3 Jackfruit-Sweet Gourd Based Agroforestry System

In this system the total cost of production for Jackfruit was 7100 Tk/ha and Total cost of production for sweet gourd was 70760 Tk/ha (Table 21), the selling price of Jackfruit and sweet gourd was 17000 Tk/ha and 119000 Tk/ha respectively. And the BCR was 1.75 which is more than sole jackfruit cultivation BCR (1.43) therefore, proves that jackfruit-based Agroforestry system is beneficial than sole jackfruit cultivation.

Table 21. Cost of Production of Jackfruit- Sweet gourd-based Agroforestry system per hectare area

Items	**Material Cost (Tk.)**	
	Jackfruit	**Sweet gourd**
Planting material cost	900	8000
Fertilizer cost	1000	11500
Irrigation application cost		3000
Instrument cost	400	1000
Items	**Non-material Cost (Tk.)**	
	Jackfruit	**Sweet gourd**
Land preparation cost		5500
Intercultural operation cost	500	6000
Labor cost	1200	12500
Harvesting cost	1000	2500
Marketing cost	1200	1500
Fixed cost	900	18560
Total cost	7100	70760
Grand total	**77860**	
Gross Return/Output:		
Items	**Jackfruit**	**Sweet gourd**
Sell price	15500	117000
Own consumption	1500	2000
Total income	**136000**	

Benefit Cost Ratio:

$$\textbf{Benefit Cost Ratio (BCR)} = \frac{\text{Gross Income}}{\text{Total Cost of Production}} = \frac{136000}{77860}$$

$$= 1.75$$

4.5.4 Jackfruit-Cucumber Based Agroforestry System

Table 22 showed that In this system the total cost of production for Jackfruit was 7950 Tk/ha and Total cost of production for cucumber was 76200 Tk/ha, the selling price of Jackfruit was 19500 Tk/ha and cucumber 112000 Tk/ha respectively. And the BCR was 1.77 which is more than sole jackfruit cultivation BCR (1.43) therefore, proves that jackfruit-based Agroforestry system is beneficial than sole jackfruit cultivation.

Table 22. Cost of Production of Jackfruit- Cucumber based Agroforestry system per hectare area

Items	**Material Cost (Tk.)**	
	Jackfruit	**cucumber**
Planting material cost	850	7500
Fertilizer cost	1200	12500
Irrigation application cost		3500
Instrument cost	500	2000
Items	**Non-material Cost (Tk.)**	
	Jackfruit	**cucumber**
Land preparation cost		7500
Intercultural operation cost	700	6000
Labor cost	1500	13500
Harvesting cost	1400	2500
Marketing cost	1300	2700
Fixed cost	500	18500
Total cost	7950	76200
Grand total	**84150**	
b. Gross Return/Output:		
Items	**Jackfruit**	**cucumber**
Sell price	28500	114500
Own consumption	2000	4500
Total income	**149500**	

Benefit Cost Ratio:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross Income}}{\text{Total Cost of Production}} = \frac{149500}{84150}$$

$$= 1.77$$

4.5.5 Comparison of Different Jackfruit Based Agroforestry Systems

Data in the table 23 shows that, Jackfruit-cucumber based Agroforestry obtained the highest cost of production 84150 Tk and highest gross income 149500 Tk. The highest net return 74800 Tk was obtained from Jackfruit-Rice based Agroforestry system. The lowest cost of production 57360 Tk is needed in case of Jackfruit-Turmeric based Agroforestry system and the net income is also lowest 53140 Tk in this system.

Table 23. Comparison of different jackfruit-based Agroforestry systems

Sl. No.	Jackfruit based Agroforestry system	Gross income (Tk./ha)	Total cost of production (Tk./ha)	Net income (Tk./ha)	BCR
1	Jackfruit-Rice	148550	73750	74800	2.01
2	Jackfruit-Turmeric	110500	57360	53140	1.92
3	Jackfruit-Sweet gourd	136000	77860	58140	1.75
4	Jackfruit-Cucumber	149500	84150	65350	1.77

Benefit cost ratio is the amount we use and the amount we get as return. If we arrange the value of benefit cost ratio (BCR) get in table 23 from higher to lower (2.01>1.92>1.77>1.75), we will see the most profitable Jackfruit based Agroforestry system. The highest benefit cost ratio is highest 2.01 for Jackfruit Rice based Agroforestry system. It means that if, a farmer invests 1 taka in Jackfruit Rice based Agroforestry system in a unit land, he will get 2.01 taka as a return from it.

4.5.6 Problems and Constraints of Jackfruit Based Agroforestry System

In this chapter, an attempt has been made to identify and analyze the major constraints faced by the farmers in Jackfruit based Argo forestry system. Generally, farmers in Bangladesh have been cultivating Jackfruit for a long period of time following the age-old method. In the study area Jackfruit farmer faced a number of problems.

4.5.7 Problems and constraints faced by the farmers

They do not get the sufficient quantities of seedlings, fertilizers, technical supports and the desirable price of their product. Due to lack of capital, they are economically not very capable of investing the required amount for Jackfruit based Argo forestry. They do not get sufficient support from government. It was observed that constraints faced by the farmers were not identical. Some relevant questions were asked to the producer of jackfruits and the summary results of the findings were classified into three categories such as

i.Economic problems
ii.Technical problems
iii.Marketing problems

Table 24. Major problems faced by the farmers in jackfruit-based Agroforestry system

Problems and constrains	No.	Percent (%)
i. Economic problems		
1.Low price of output	36	60
2.High price of inputs	39	65
3.Lack of capital or institutional credit	34	56.66
4.Seasonal labour shortage and high wage rate	23	38.33
ii. Technical Problems		
1.Lack of extension services	25	41.67
2.Lack of scientific knowledge and method	23	38.33
3.Lack of good quality seedlings	21	35
4. Attack by pest and disease	18	30
iii. Marketing problems		
1.Inadequate storage facilities	38	63.33
2.Dominance of intermediaries	36	60
3.Lack of transportation facilities	26	43.33
4.Lack of market information	15	25

Some jackfruit growers said that they did not get fair price of jackfruits, despite repeated bumper productions year after year, due to a lack of adequate marketing facilities. jackfruit prices have fallen due to huge supply. People do not want to eat jackfruit due to the heatwave.

Rahman (2015) carried out a study on farmers problems and prospects of jackfruit commercialization in Bhaluka upazila of Mymensingh district. By using Problem and Prospects Appearance Index (PPAI) his study result revealed that three fourth (67.4%) portion of the farmers experienced moderate problem and majority (79.1%) of them

perceived medium level prospects of jackfruit commercialization. In Bangladesh, 35 species of insect pests and diseases attack jackfruit plant (Alam, 1974). Shoot and stem borer are the major insect pests of jackfruit. Stem and fruit rots, Gummosis, Bacterial dieback are the major diseases of Jackfruit.

4.5.8 Probable Solutions

In the study area Jackfruit producers were asked to suggest solutions of the problems identified above**.** Following suggestions were presented by the farmers for an overall improvement of jackfruit production:

i. Measures should be taken to ensure timely supply of fertilizers to the farmers at government subsidized price.
ii. On the basis of easy terms and conditions, institutional credit should be made available to the farmers for increasing production of jackfruit as well as enhancing their sustaining power.
iii. Most of the farmers suggested that input price like price of seedlings, fertilizers, should be reduced in order to minimize production cost.
iv. Imparting short training for the farmers and to let them know about the modem technology of jackfruit based Agroforestry system. They also expressed the need to the appropriate and affordable technology for harvesting and planting to minimize the labour cost which would encourage the farmers for intensive cultivation for more production because of higher profit.
v. Communication and transportation facilities should be improved to facilitate the marketing process.
vi. Proper storage facilities should be developed at the local markets in order to lessen extent jackfruit wastage.
vii. Reasonable market toll should be fixed for all markets and it should be regulated by a responsible authority.

Majumder (2011) reported that low jackfruit prices have caused challenges for local farmers in eight upazilas in Khagrachhari's hilly area, where big yields were expected. In his report, he described how a farmer named Abul Kashem from Taindong village in

Matiranga upazilla lost Tk. 800 after selling 4,000 jackfruits for only Tk. 25,000. In this case, he blamed a bad transport system, cheaper prices, and a lack of government market regulation.

4.6 Identification of Value-Added Products of Jackfruit

Jackfruit has great potential for value addition for minimizing post-harvest loses and enhancing the nonseasonal availability. More than 100 items can be prepared from jack fruit right from immature stage to well ripened stage (Table 25). The importance of the fruit, seed and rind is known very little to the growers and consumers. Absence of organized marketing strategies among the growers' results in wastage of major quantity of the jackfruit produced. Hence, value addition is important to utilize the surplus fruits available during the season as well to improve the livelihood of the farmers by producing value added products.

Table 25. Use of jackfruit at different stages

Value added products	Responds	Percent (%)
Unripe jackfruit		
As vegetable	54	90
Pickle	8	13.33
Chips	0	0
Half-ripe jackfruit		
Candy	0	0
Preserve	14	23.33
Ripe jackfruit		
RTE(Ready to eat)	60	100
Jam	5	8.33
Jelly	4	6.66
Cake	14	23.33
Chutney	12	20
Canned pulp	42	70
Leather	0	0
Jackfruit seed		
As vegetable	60	100
Seed powder	15	25
Starch flour	0	0
Halwa	12	20

Table 25 showed that 100% respondents eat ripe jackfruit, 90 % responds use unripe jackfruit as vegetable, 23.33 % respondents preserve half ripe jackfruit and 100 % respondents use seed as vegetables. They do not know the use of jackfruit as Chips, Candy, Leather and starch flour. The seed flour was effectively used in some food. In the research

work the biscuit with 20% concentration of jackfruit seed flour with different particle size was prepared. Bhuyan *et al*. (2013) reported that if the mature green jackfruits washed with clean water, peeled and cut into small pieces, kept in 8 per cent salt, 1.25 per cent acetic acid, 0.1 per cent KMS and 91.65 per cent water solution, the materials are poured into air tight plastic container and can store in cool and dry place. Hossain *et al*. (1979) found that the jackfruit is rich in carotene and carbohydrates and moderately rich in ascorbic acid. It also contains some minerals like calcium and potassium and Vitamin B like thiamin, riboflavin and niacin. The large sized seeds are boiled or roasted and eaten as such or made into cooked vegetable. The seeds are reported to be more nutritious than the bulb, being richer in protein, fat, potassium and carbohydrate with considerable amount of phosphorus and calcium.

4.6.1 Use of Jackfruit trees

Jackfruit timber is widely used in the manufacture of furniture, doors and windows, in roof construction, and fish sauce barrels. The wood of the tree is used for the production of musical instruments. The golden yellow timber with good grain is used for building furniture and house construction in Bangladesh. It is termite-proof and is superior to teak for building furniture.

Table 26. Use of Jackfruit trees

Items	Respondents	Percent (%)
Furniture	60	100
Fuel	60	100
Fodder	44	73.33
Resin	5	8.33
burnish	7	11.66

Data in table 27 show that 100 % respondents use jackfruit timber as furniture and fuel. 73.33 %, 8.33% and 11.66 % use as fodder, resin and burnish respectively.

4.6.2 Constraints

Jackfruit is an under-utilized fruit crop across the country. Beside from scattered home scale pickle and chips making, there is no significant value addition activity happening anywhere in our country. Most of the consumption happening at the household level. Despite the fact that there is a demand for Jackfruit value added products in the mainland. Fruits are rotting under the trees due to transportation hurdles, negligence and non-availability of value-addition opportunities including awareness about its potential for income generation amongst both the rural and urban communities. A large part of the value-addition activity takes place in the unorganized sector.

A stable marketing chain is not in existence for jackfruit. At the village level, collectors from outside as well as those from the village itself purchase the fruits and sell them in external markets, mainly at village fairs and roadside sheds. Middlemen decide the market prices resulting in the exploitation of the producers.

No standard post-harvest handling practices are followed. As a result, post-harvest loss is enormous in particular because the packaging materials are of very poor quality, generally consisting of bamboo baskets or second-hand cartons. Packaging of the fruit is very tough due to the shape, size, and weight which is not uniform. It cannot be packaged in standard-sized crates and boxes like other fruits. Only the form-fleshed ripe fruit is preferred for eating once it is ripe. This type of fruit is comparatively less common to the soft-fleshed fruit. Additionally, there is no scientific way to recognize if the fruit is in good condition or rotten from the outside.

Availability of processed products in the local market is low due to lack of interest shown by the producers. However, primary processing at the household level using traditional methods was reported only for local consumption but these traditional products are still scarce in the market.

Table 27. Constraints of value-addition

Constraints	Responds	Percent (%)
Knowledge about Value added product of Jackfruit	50	83.33
Traditional methods of processing	45	75
Transportation	37	61.66
No stable marketing chain	52	86.66
No standard post-harvest handling practices	53	88.33
Packaging	46	76.66

According to Khandaker *et al*. (2009), proper marketing infrastructure is critical for effective fruit marketing. Appropriate transportation and product handling are also critical for agricultural product trade, as well as ensuring fair prices and poverty reduction

4.6.3 Developing Jackfruit Cultivation, Reduce Wastage of Fruits and Enhance Value-Addition:

The Jackfruit industry is at a very nascent stage in our country and has a long way to go to reach its potential. There are a number of challenges facing the industry right from the cultivation stage to the retail and marketing of value-added products. Such challenges can be tackled through the following steps:

- Encouraging ‘grafting’ with that high-yielding varieties of jackfruit.
- Promoting appropriate package of practices.
- Facilitate adoption of appropriate harvesting practices and post-harvest technology.
- Encourage the practice of ‘grading’ at farmer’s level.
- Promotion of ‘nano’ enterprises for ‘minimal’ processing of jackfruit.
- Strengthening existing SMEs through a variety of interventions such as Management Development, Technology Upgradation, Export Promotion etc.

- Facilitate credit linkages (to meet the cost of new equipment and allied facilities) through formal banking channels or through a micro credit delivery mechanism.
- Provide Technical support, specially related to adoption of a mix of jackfruit varieties and use of better ‘package of practices’ through existing apparatus of Agriculture/Horticulture Department of the State government.

Ahmmed (2010) reported that the postharvest problem of jackfruit was 16.13 percent, 11.40 percent, 9.22 percent and 6.76 percent at the 'growers', 'Bepari', 'wholesalers', and ‘retailers' levels, respectively, and that the total postharvest loss of jackfruit in the entire supply chain was estimated to be 43.51 percent.

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

In the light of discussion made in earlier chapters, a summary of the results, conclusions on the basis of the empirical findings are presented in this chapter. Some important policy recommendations to improve the existing status of jackfruit-based agroforestry systems and Scope for future study in Bangladesh are also presented in this chapter.

SUMMARY

The study was conducted at three unions of Netrokona district to identify the different jackfruit-based Agroforestry system, economic potentialities and value addition. So, respondents were selected randomly and data were collected by questionnaire during January to December 2020. Data were analyzed by SPSS 16.0 package program. The maximum respondents were young age (46.67%) where the minimum was old age (16.66%). However, the maximum respondents (35%) were under primary education and the minimum respondents (8.34%) were under above HSC education. Among the respondents' maximum farmers (46.67%) had medium size family and the minimum farmers (11.66%) had large family. Among the respondents, agriculture was the primary occupation for the maximum (46.67%) respondents where minimum number of respondents (5%) was in others like day lobour, rickshaw puller etc. Majority of the farmers (83.33%) earned medium annually and the minority (25%) earned low income in a year. Majority of the respondents (53.33%) had medium size farm and minority (18.33%) had large size farm.

only (28.33%) respondent preferred sole jackfruit. On the other hand, most of the respondent preferred (71.66%) jackfruit-based agroforestry system. The most frequently jackfruit-based agroforestry systems were Jackfruit- rice based Agroforestry (65.00%), Jackfruit-Turmeric based Agroforestry (60%), Jackfruit-Lotkon based Agroforestry (56.25%), Jackfruit-Sweet gourd based Agroforestry (47.25%), Jackfruit-Cucumber based Agroforestry (51.25%). The highest 40 percent farmers practiced Jackfruit farming for 10-15 year and 31.66 percent farmers practiced Jackfruit cultivation for more than 15 years.

Maximum (51.66%) of the farmers had medium income from Jackfruit based agroforestry system. 20% farmers had high income and the rest 28.33% farmers had low income. The highest proportions 41.67 percent of the respondents had below 0.04 ha of land where only 20 percent had above 0.08 ha of land in which they have applied Jackfruit based Agroforestry system. About 46.67 percent farmers had 10 to 20 Jackfruit trees and 11.67 percent had less than 10 trees. By observing 15 years of jackfruit cultivation the BCR was calculated as 1.45 which is beneficial. And from intertemporal budgeting the DBCR was calculated 1.26 and IRR was 41.91%. Jackfruit-Rice BCR was 2.01, Jackfruit-Turmeric BCR=1.92, Jackfruit-Lotkon BCR=1.79, Jackfruit-Sweet gourd BCR=1.75 and Jackfruit-Cucumber BCR =1.77 so, we can say that the jackfruit-based agroforestry system is more profitable than sole jackfruit cultivation. Most of the farmers (65%) identified High price of inputs and 63.33% respondents identified Inadequate storage facilities as problems faced by them. About 100% respondents eat ripe jackfruit, 90 % responds use unripe jackfruit as vegetable, 23.33 % respondents preserve half ripe jackfruit. Here 100 % respondents use jackfruit timber as furniture and fuel. 73.33 %, 8.33% and 11.66 % use as fodder, resin and burnish respectively. A stable marketing chain is not in existence for jackfruit. No standard post-harvest handling practices are followed. As a result, post-harvest loss is enormous in particular because the packaging materials are of very poor quality, generally consisting of bamboo baskets or second-hand cartons. Availability of processed products in the local market is low due to lack of interest shown by the producers. Primary processing at the household level using traditional methods was reported only for local consumption but these traditional products are still scarce in the market.

CONCLUSION

The following conclusions were drawn based on the findings of the present study:

1. Jackfruit-based Agroforestry system is more profitable than sole jackfruit cultivation. In the study area four types of jackfruit-based Agroforestry system were identified and jackfruit-rice based system held the highest BCR (2.01) among them.
2. The discounted benefit cost ratio (1.26), and internal rate of return (41.91%) clearly indicated that jackfruit-rice based agroforestry system was productive and profitable agroforestry system.
3. Most of the respondents eat ripe jackfruit, use unripe jackfruit as vegetable, preserve half ripe jackfruit and use seed as vegetables. Utmost do not know the value-added products of jackfruit as chips, candy, leather and starch flour.

Therefore, it can be concluded that farmers of this region can be more benefited by applying different techniques of value-added products from jackfruits based agroforestry systems.

RECOMMENDATIONS

Some recommendations can be made on the basis of present investigation as follows:

1. Department of Agricultural Extension (DAE) should take necessary actions to encourage more jackfruit cultivation through providing new technologies to the farmers about jackfruit tree cultivation.
2. Research program should be conducted to identify the best jackfruit-based agroforestry system and to imply them for practicing.
3. A good marketing system is hampered due to some severe problems.
4. A considerable damage was occurred due to lack of marketing facilities and price return was not also desirable as their demand. So, marketing problems should be removed by improving marketing infrastructure and communication. Marketing and communication facilities from primary producers to organized markets should be improved for having fair prices of the outputs.

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APPENDICES

Appendix 1. Questionnaire of The Study

(English Version of the Interview Schedule)

Department of Agroforestry and Environmental Science

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

Dhaka-1207

Questionnaire on

AGROECONOMIC PERFORMANCE OF JACKFRUIT BASED AGROFORESTRY SYSTEMS AND VALUE-ADDED PRODUCT OF JACKFRUIT IN NETROKONA DISTRICT

A . Personal Details

1. Identification of the respondent

   Name:……

   Fathers name:……

   Mothers name:…….

   Village:……..Upazilla:…….

   District:……..Age:……Occupation:……
2. Education Level: No education/Primary/SSC/HSC/Avobe HSC
3. Family status: Single/Combined
4. Number of Household Members: Total:…….Male:……..Female:……
5. Are you a member of any local Organization? Yes/No

   Name……

   Duration of Membership:……..

6. Information on land holding

Items	Area(decimals)
Homestead area	
Own cultivated land	
Rented in	
Rented out	
Mortgaged in	
Mortgaged out	
Fallow land	
Others(……..)	
Total	

7. Household income from different income generating activities(per year)

<table>
<tr><th colspan="2">Income generating activities</th><th>Amount Tk.</th><th>Income generating activities</th><th>Amount Tk.</th></tr>
<tr><td rowspan="4">Crop farming</td><td></td><td></td><td rowspan="4">Business</td><td rowspan="4"></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Livestock farming (Cattle/Goat)</td><td></td><td>Gift/Social safety net</td><td></td></tr>
<tr><td colspan="2">Poultry farming</td><td></td><td>Remittance</td><td></td></tr>
<tr><td colspan="2">Fish farming</td><td></td><td>Rickshaw/van pulling</td><td></td></tr>
<tr><td colspan="2">Service</td><td></td><td>Others(if any)
…….</td><td></td></tr>
</table>

B. Detail history and purpose of cultivation:

1. From when and how have you related with Jackfruit based agroforestry system?

2. Why do you choose Jackfruit based agroforestry system in your crop land?
   I. Own occupation
   ii. Sale/Business
   iii. Both
   iv. Traditionally
3. Total cultivated land area……acre/hectare/bigha/khata
4. Land area under jackfruit based agroforestry system?
   ……..... acre/hectare/bigha/khata
5. How long have you been practicing Jackfruit based agroforestry system?.....years
6. Number of Jackfruit Trees Owned by Farmers……..
7. What is the age of Jackfruit tree ?.....years
8. Which crop do you prefer to cultivate with Jackfruit?
9. Why you will choose this crop?
10. Which location that you prefer to collect the associated crops?

11. What are the major problems/ constraints are you facing in jackfruit production?
    a)
    b)
    c)

C. Cost of Production and Net income:

1 . Cost of production

Items	Material Cost (Tk.)	
	Jackfruit	Others crop
Planting material cost		
Fertilizer cost		
Pesticide application cost		
Instrument cost		
Items	Non-material Cost (Tk.)	
	Jackfruit	Others crop
Land preparation cost		
Intercultural operation cost		
Labor cost		
Harvesting cost		
Marketing cost		
Fixed cost		
Total cost		
Grand total		

2. Net Return/Output:

Items	Jackfruit	Others crop
Sell price		
Own consumption		
Total income		

D. Value addition of Jackfruit

1. Do you know about value addition? Yes/No
2. How is it possible to value addition of this fruit?

3. Use of jackfruit at different stages

Stage of Jackfruit	Value added products						
unripe jackfruit	As vegetable	Pickle	Chips				
half-ripe jackfruit	Candy	Preserve					
ripe jackfruit	RET (Ready to eat)	Jam	Jelly	Cake	Chutney	Canned pulp	Leather (Amsatt)
Jackfruit seed	As vegetable	Seed powder	Starch flour	Halwa			

4. What is the use of jackfruit timber?

5. Is it a source of enhanced revenue to the producer? Yes/No
6. Is it aggregated and marketed as a locally produced agricultural food product? Yes/No
7. What are the post harvest losses in jackfruit during the peak season? How can it be minimized?

8. What are the major problems/ constraints are you facing in value addition in jackfruit?

(Thank You for Your Cooperation)

Date:…….. Signature:…….

Appendix 2. Distribution of Respondents According to Age, Education, Family Size and Annual Income

Characteristics	Category	Range		Mean	Frequency	Respondent (%)
		Minimum	Maximum			
Age (years)	<40	26	65	47.70	22	36.67
	40-50				28	46.67
	>50				10	16.66
Education	Illiterate (0)	0	16	6.4	14	23.33
	Primary (1-5)				21	35
	Secondary (6-10)				11	18.33
	HSC education (11-12)				9	15
	above HSC (>12).				5	8.34
Family size (No. of people)	Small family (up to 5)	3	12	7	25	41.67
	Medium family (5-10)				28	46.67
	Large family (above 10)				7	11.66
Annual income (000 tk.)	Low income (Up to 50000)	28	400	210	15	25
	Medium income (50500-150000)				23	83.33
	High income (above 150000)				22	36.67

Appendix 3. Some Photographs Related to The Study

Plate 1. Data collection from farmer in Madanpur union

Plate 2. Data collection from farmer in Lakshmiganj union

Plate 3. A field of Jackfruit-Turmeric based Agroforestry system

Plate 4 . A field of Jackfruit-Cucumber based Agroforestry system

Plate 5 . A field of Jackfruit-Sweet gourd based Agroforestry system

Plate 6 . Jackfruit-pickle

Plate 7. Jackfruit Jelly

Plate 8 . Jackfruit Seed Flour