

Project ID 439

Competitive Research Grant

Sub-Project Completion Report

on

Evaluation of tree-crop interaction from existing agroforestry systems in Sylhet region for food security by the lens of Climate-Smart Agriculture framework

Project Duration

10 July 2017 to 30 September 2018

Department of Agroforestry and Environmental Science
Sylhet Agricultural University, Tilagor, Sylhet 3100

Submitted to



Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215



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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
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Acronyms

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
FGD	=	Focus Group Discussion
<i>et al.</i>	=	et alii (and others)
ha	=	Hectare
hrs.	=	Hours
i.e.	=	id est. (that is)
N	=	Nitrogen
No.	=	Number
OM	=	Organic matter
P	=	Phosphorus
plant ⁻¹	=	Per plant
RCBD	=	Randomized Complete Block Design
S	=	Sulfur
SD	=	Standard deviation
SRDI	=	Soil Resources Development Institute
LSD	=	Least significance difference test

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Executive Summary

The project was implemented during July 2017 to September 2018 at Jaintiapur and Golapgonj upazila of Sylhet district and Barlekha upazila of Moulvibazar district with views to document the status of agroforestry as well as other climate-smart agricultural practices and performance of different agar based agroforestry systems. Field survey, Focus Group Discussion (FGD) and field experiments were conducted to fulfill the objectives of the project. The survey was conducted in Jaintiapur and Golapgonj upazila of Sylhet district, Bangladesh during July 2017 to July 2018 to document the status of agroforestry as well as other climate-smart agricultural practices. A random sampling technique was followed to select the sample farmers. Total numbers of sample farmers were 60 and 102 in Golapgonj and Jaintiapur upazila, respectively. The field experiment was conducted with thirteen treatments of six different demandable species and an agar plant in Barlekha upazila of Moulvibazar districts during February 2018 to September 2018 to examine the performance of agar plant and crops under sole and agroforestry systems following Randomized Complete Block Design (RCBD) with three replications.

In Golapgonj upazila, total 86 plant species were recorded of which 38 were timber and fruit species, 29 were vegetable species, 12 were medicinal species, and 7 were spice species. Thirty two production activities were reported in which rice, guava, vegetable, betelnut were major (>70%) production activities while betel leaf, toikor, drumstick, black pepper and apiculture were minor (<14%) production activity. 29 plant species increased in the study area in which acacia, guava, betel nut and tomato are the most. In Jaintiapur upazila, total 97 agroforest plant species were found in which 28 fruit trees, 27 vegetables, 13 timbers, 11 medicinal, 9 spices, 5 crops and 4 non-timber species. Thirteen production activities were reported in which homestead agroforestry, livestock farming, field crop production, roadside agroforestry and citrus based agroforestry production were major (>70%) production activities while drumstick production, apiculture and agar plantation were minor (<14%) production activity in the study area. 31 plant species increased in the study area in which acacia, rain tree, rice, Jack fruit are the most.

In Golapgonj upazila, 17 Climate-smart agricultural (CSA) practices were identified. Those practices were high yielding variety (78.3%), perching (63.3%), adjusting planting time (51.6%), mulching (46.6%), farm yard manure (46.6%), short duration varieties (46.6%), IPM (43.3%), intercropping (38.3%), crop rotation (38.3%), pheromone trap (35%), use of local pesticides (35%), improved livestock breed (25%), agroforestry (23.3%), vermicomposting (23.3%), Sorjan (21.6%), light trap (13.3%), rice-cum-fish farming (10%). In Jaintiapur upazila, 19 CSA practices were identified. Those practices were perching (84%), high yielding varieties (79%), adjusting planting time (74%), farm yard manure (65%), green manuring (63%), crop rotation (57%), vermicomposting(53%), cover crop(59%), fallowing(45%), rain water harvesting(38%), alternate wetting and drying(38%), improved livestock breed(36%), community seed bed(30%), urea super granule(27%), integrated pest mangement(26%), sorjon method(25%), floating bed fodder(19%), zero tillage(18%) and raised bed planting(11%). They were categorized into six CSA pools *i.e.*, pest smart, carbon smart, nutrient smart, water smart, weather smart and knowledge smart. However, the levels of use of climate-smart practices were not satisfactory in both the study area. Finally, a three-tier up-scaling approach *i.e.*, information-transfer approach, entrepreneur development approach and policy inclusion approach were proposed for the dissemination of CSA practices as short, medium and long term strategy for the study sites which might be also applicable for the other areas of Sylhet region. Results revealed from the field experiment that the crops can be grown in the existing agar garden as agroforestry systems without hampering the growth and development of agar plant. Tea (*Camellia sinensis*) is the most suitable as associated crops with agar plant followed by ginger (*Zingiber officinale*), pineapple (*Ananas comosus*) and bilati dhonia (*Eryngium foetidum*) which provide the additional year round production from existing agar garden.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project:

Evaluation of tree-crop interaction from existing agroforestry systems in Sylhet region for food security by the lens of climate-smart agriculture framework

2. Implementing organization:

Department of Agroforestry and Environmental Science, Sylhet Agricultural University, Tilagor, Sylhet 3100.

3. Name and full address with phone, cell and E-mail of PI and Co-PI (s):

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4. Sub-project budget (Tk):

4.1 Total: Tk. 23,50,000.00 (Twenty Three Lac & Fifty Thousand Taka)

4.2 Revised : 23,50,000.00 (Twenty Three Lac & Fifty Thousand Taka)

5. Duration of the sub-project:

5.1 Start date (based on LoA signed): 10 July 2017

5.2 End date: 30 September 2018

6. Justification of undertaking the sub-project:

Agroforestry has been an integral part of rural livelihood for centuries in many countries of the world including Bangladesh. It plays a vital role in keeping the land base productive and by providing household food and energy security, income and employment generation, investment opportunities and environmental protection (Miah *et al.* 2002; Batish *et al.* 2007; Bardhan *et al.* 2012). In addition to providing clean water and clean air and other ecosystem services (Jose 2009), agroforestry systems also help supply fuelwood, fodder, timber, and improve socioeconomic condition of the farmers (Alam 2004; Rahman *et al.* 2017). The accepted standard according to the experts of environmental science is that a country has at least 25 percent of its total land area covered with trees or forests (Huda and Roy, 1999). Once covered by dense forests, Bangladesh is now almost devoid of forest land, except in few selected areas of the country (Giri and Shrestha, 1996), in terms of per capita forest land, Bangladesh ranks amongst the lowest in the world, which is about 0.02 ha per person (UNEP, 2002). For this above situation i.e. increased population and deforested condition, agroforestry practices will be an appropriate alternate land management option.

Crop production has been evolving since the domestication of crop species 10000 years ago. The best known and documented example of this is the Green Revolution, which swept through much of the developing world during the 1960s. The Green Revolution was characterized by the planting of high-yielding crop varieties, with the associated chemical package and irrigation. As a result, farmers increased cereal food production from 800 million tons to over 2.2 billion tons between 1961 and 2000. In many countries, decades of intensive cropping have degraded fertile land, depleted groundwater, triggered an upsurge in pests, eroded biodiversity and polluted the air, water and soil. Intensive crop production is no longer sustainable, and a new paradigm should emerge – and this is what save and grow – *i.e.* sustainable crop production intensification – is about (FAO, 2011). It means a productive agriculture that conserves and enhances natural resources through an ecosystem approach that capitalizes on

natural biological inputs and processes.

The Food and Agriculture Organization (FAO) defines climate-smart agriculture (CSA) as agriculture that sustainably increasing productivity to support equitable increases incomes, food security and development; adapting and building resilience to climate change from the farm to national levels; and developing opportunities to reduce Greenhouse Gas (GHG) emissions from agriculture compared with past trends (Lipper *et al.* 2014). Climate Smart Agriculture aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience to climate change and reducing greenhouse gas emissions, where possible. There are two ways by which agricultural production can contribute to mitigate climate change, i.e., (i) to improve efficiency by decoupling production growth from emissions growth, and (ii) to enhance soil carbon sinks (FAO, 2013). Researchers have conducted field trials and experiments to determine the 'climate-smart' potential of many different farming techniques (Smith *et al.* 2008). It has been determined that not every technique is appropriate for every soil, climate, landscape, or socio-economic situation (Bryan *et al.* 2013). With the right practices, policies and investments, the agriculture sector can move onto CSA pathways, resulting in decreased food insecurity and poverty in the short term while contributing to reducing climate change as a threat to food security over the longer term (Lipper *et al.* 2014).

Bangladesh is one of the most vulnerable countries to the impacts of climate change in the world. According to the Global Climate Risk Index (GCRI) in 2017, Bangladesh was the sixth most climate-vulnerable country in the world (Kreft *et al.* 2017), though during 2010 it was the most climate-vulnerable country (Harmeling, 2009). Farmers introduced climate smart agricultural practices through a large number of agricultural innovations by their own initiative and with the financial and technical support of various government and nongovernment organizations.

Onyeneke *et al.* (2017) identified five broad and important practices relevant to climate smart agriculture practices namely, adjusting agricultural production systems, mobility

and social networks, farm financial management, diversification on and beyond the farm, and knowledge management and regulations. Hasan *et al.* (2018) identified seventeen CSA practices *viz.* saline-tolerant crop varieties, flood-tolerant crop varieties, drought-resistant crop varieties, early maturing rice, vegetables in a floating bed, sorjan method of farming, pond-side vegetable cultivation, the cultivation of watermelon, sunflower or plum, relay cropping, urea deep placement, organic fertilizer, mulching, use of pheromone trap, rain water harvesting and seed storage in plastic bags or glass bottles in Kalapara upazila in Patuakhali, Bangladesh. Billah and Hossain (2017) also reported cultivating HYV, zero tillage, crop diversification, crop rotation, intercropping, mulching, improved irrigation, use of stress tolerant varieties, integrated farming system, rain water conservation, agroforestry, box ridges, alternate wet and drying (AWD) method, pit planting and short duration varieties as existing CSA technologies practiced by the coastal farmers. Climate-smart-agricultural practices have significant role on food security through sustainable crop production in Bangladesh (Billah and Hossain, 2017; Hasan *et al.* 2018).

The population of Bangladesh is increasing at an alarming rate and the cultivable land is reducing due to urbanization and industrialization resulting in more shortage of food along with the crop loss due to climatic hazards. Therefore, Bangladesh urgently needs support in developing and expanding a climate-smart agriculture if its people are to survive and prosper in the long term. As it is not possible to control climatic hazards or cannot completely remove this hazard; climate smart farming practices for crop production need to be introduced and analyzed to meet this ever-increasing demand of food in the Eastern Indo Gangetic Plain and to sustain resilient agriculture.

In Bangladesh, several traditional and modern agroforestry systems are familiar in different agroecosystem of Bangladesh. Although agroforestry systems are found throughout the country, they vary due to variations in topography, soils, water regimes, climate, and socioeconomic conditions. Now-a-days, farmers of Bangladesh are practicing several modern agroforestry production systems based on both fruit and

timber species (Miah and Hussain 2005; Rahman *et al.* 2016). Fruit tree based agroforestry systems are capable of providing higher yield and economic returns, and grown under various biotic and abiotic stressed conditions compared to that of many annual crops (Bikash *et al.* 2008). Many of the practices, such as agar (*Artocarpus heterophyllus* Lam.) based system in the hilly region, date palm (*Phoenix sylvestris* L.) and palmyrapalm (*Borassus flabellifer* L.) based system in the southeast and mango (*Mangifera indica* L.) based system in the northeast regions are well suited to smallholdings under sub-optimal management and subsistence farming conditions. These traditional agroforestry systems have been contributing to the livelihood of the rural households in Bangladesh by providing diversified products (Abedin and Quddus 1990; Akter *et al.* 1990).

Khan (2007) identified a large number of major and minor traditional and new agroforestry systems in terrace ecosystem of Bangladesh. Burmese grape based agroforestry systems are also found as an economically viable practice in some areas of terrace ecosystem (Alam, 2004). These systems are traditionally managed with low inputs and low technological support resulting in low yield and income. Many sole agar gardens are widely distributed, but are not well managed. These gardens usually give poor yield, although there are enough opportunities to achieve high yield potential from such gardens through inclusion of cash crops. Multistoried agroforestry systems with a fruit or timber tree in the overstory and vegetables or tuber species in the understory have the potential to improve production potential of these systems. It could be a good model of association between integration of forest resources and cultivation of cash crops in the form of a sustainable and flexible system.

7. Sub-project goal:

Increasing productivity through introduction of sustainable agroforestry technology

8. Sub-project objectives:

- To document the composition and diversity of existing agroforestry practices,

- To analyze the explanatory factors responsible for the adoption of agroforestry as well as Climate-Smart Agriculture practices,
- To identify environmentally friendly, economically profitable and socially acceptable agroforestry practices in Sylhet region.

9. Implementing locations:

The study area is located at Jaintiapur and Golapgonj upazila under Sylhet district and Barlekha upazila under Moulvibazar district.

10. Methodology in brief:

The methodology of research work composed of field survey for documentation and understanding responsible factors for adoption of agroforestry and climate-smart agriculture practices, soil sample and plant composition analysis from major agroforestry practices for finding environmentally, economically and socially suitable agroforestry practices, and experimentation of promising agroforestry practices for demonstration in field laboratory to fulfilled the objectives.

10.1. Climatic condition of the study areas

10.1.1. Climatic Condition of Moulvibazar district

Major meteorological variables e.g., daily precipitation, daily air temperature (minimum, maximum, average) and daily sunshine hour during 1985-2014 from Sreemangal were collected from Bangladesh Meteorological Department (BMD) for understanding the climatic condition of Moulvibazar district.

10.1.1.1. Rainfall

The average annual rainfall from the periods of 30 years (1985-2014) was 2302 ± 489 mm in Moulvibazar. The highest monthly average rainfall was 417 ± 209 mm in May followed by 411 ± 158 mm, 342 ± 157 mm, 332 ± 93 mm and 273 ± 88 mm in June, July, August, and September, respectively whereas the monthly average lowest monthly rainfall was 6 ± 11 mm in January followed by 11 ± 31 mm, 27 ± 31 mm, 35 ± 51 mm and 80 ± 66 mm in December, February, November and March, respectively from 1985- to 2014 (Figure 1). As the experiment was

conducted from February to August 2018, the rainfall was above normal, which was good for the growth of the plant.

10.1.1.2. Air Temperature

In Moulvibazar, annual average temperature from the periods of 30 years (1985-2014) was $25.05 \pm 0.29^\circ\text{C}$. The monthly highest average temperature was $28.89 \pm 0.33^\circ\text{C}$ in August whereas the monthly lowest average temperature was $17.36 \pm 0.71^\circ\text{C}$ in January. The monthly highest maximum temperature was $32.91 \pm 1.30^\circ\text{C}$ in April whereas the monthly lowest maximum temperature was $24.94 \pm 0.93^\circ\text{C}$ in January. The monthly highest minimum temperature was $25.26 \pm 0.27^\circ\text{C}$ also in August whereas the monthly lowest minimum temperature was $9.79 \pm 0.98^\circ\text{C}$ also in January (Figure 2).

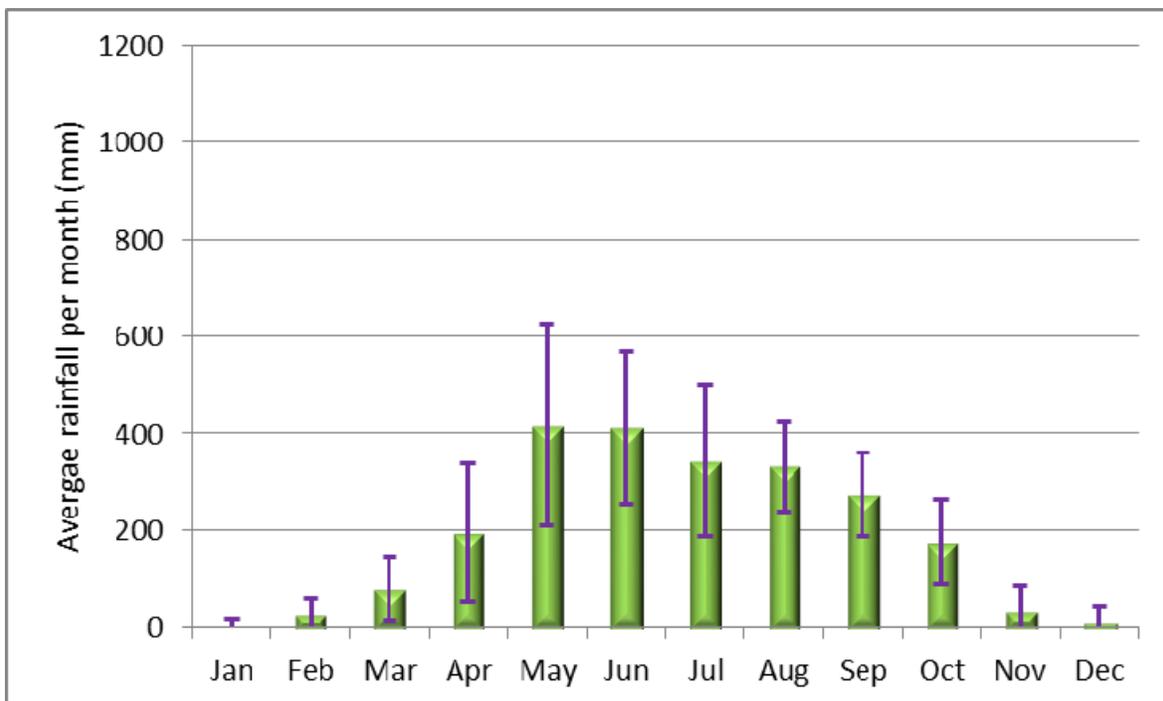


Figure 1 Average rainfall per month of Moulvibazar from the periods of 30 years (1985-2014). Bars represent the standard deviation (\pm)

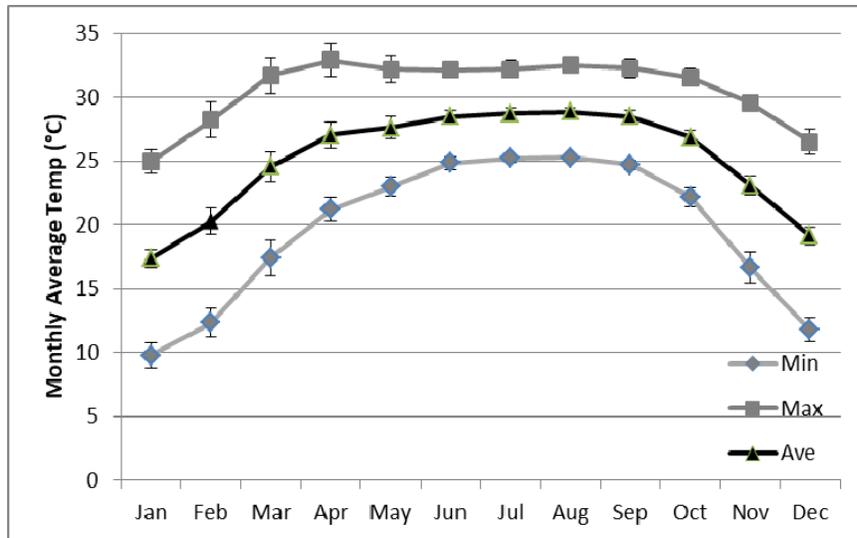


Figure 2 Average temperature (°C) per month of Moulvibazar from the periods of 30 years (1985-2014). Bars represent the standard deviation (\pm)

10.1.1.2.1 Sunshine Duration

In Moulvibazar, annual average sunshine hour from the periods of 30 years (1985-2014) was 6.33 ± 0.39 hr/day. The monthly highest average sunshine hour was 7.87 ± 1.00 hr/day in November whereas the monthly lowest average sunshine hour was 4.26 ± 0.93 hr/day in July (Figure 2.1).

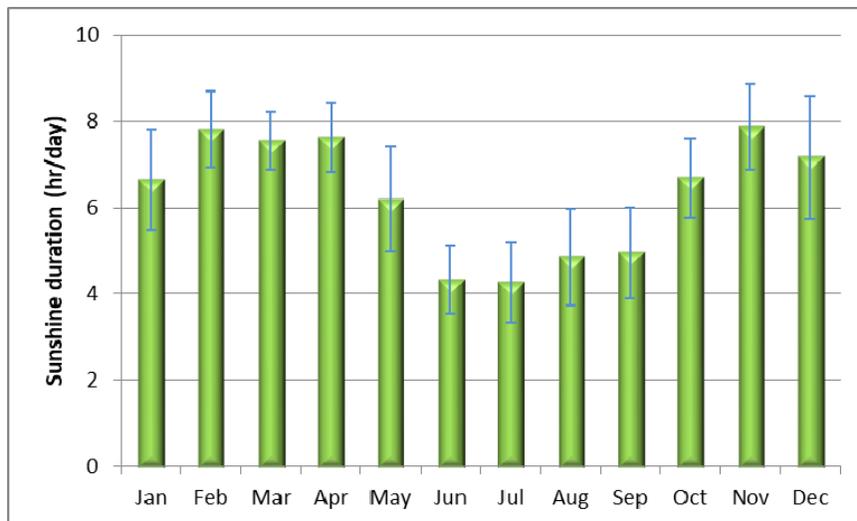


Figure 2.1 Average sunshine duration (hr/day) per month of Moulvibazar from the periods of 30 years (1985-2014). Bars represent the standard deviation (\pm)

10.1.2. Climatic condition of Sylhet region

Major meteorological variables e.g., daily precipitation, daily air temperature (minimum, maximum, average) and daily sunshine hour during 1988-2017 of Sylhet were collected from Bangladesh Meteorological Department (BMD) for understanding the climatic condition of Sylhet region.

10.1.2.1. Precipitation

The average annual rainfall from the periods of 30 years (1988-2017) was 4094 ± 642 mm in Sylhet. The highest monthly average rainfall was 791 ± 237 mm in June followed by 726 ± 273 mm, 632 ± 175 mm, 601 ± 208 mm and 535 ± 240 mm in July, August, May and September, respectively whereas the monthly average lowest monthly rainfall was 7 ± 11 mm in January followed by 9 ± 21 mm, 30 ± 44 mm and 39 ± 40 mm in December, November and February, respectively from 1988 to 2017 (Figure 3).

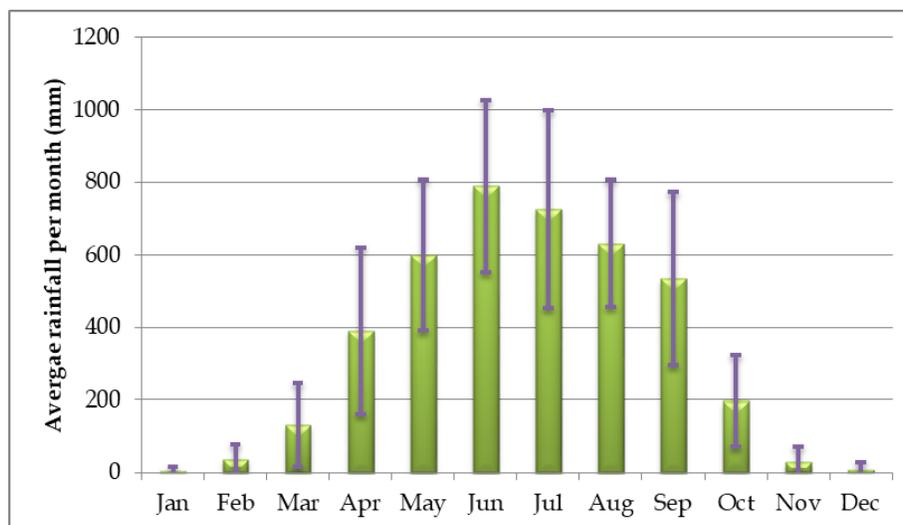


Figure 3 Average rainfall per month of Sylhet from the periods of 30 years (1988-2017). Bars represent the standard deviation (\pm)

10.1.2.2. Air temperature

In Sylhet, annual average temperature from the periods of 30 years (1988-2017) was 25.10 ± 0.48 °C. The monthly highest average temperature was 28.90 ± 0.57 °C in August whereas the monthly lowest average temperature was 19.35 ± 0.95 °C in January. The monthly highest maximum temperature was 32.37 ± 0.80 °C in August whereas the monthly lowest maximum

temperature was 25.83 ± 1.73 °C in January. The monthly highest minimum temperature was 25.45 ± 0.42 °C also in August whereas the monthly lowest minimum temperature was 13.02 ± 0.85 °C also in January (Figure 4).

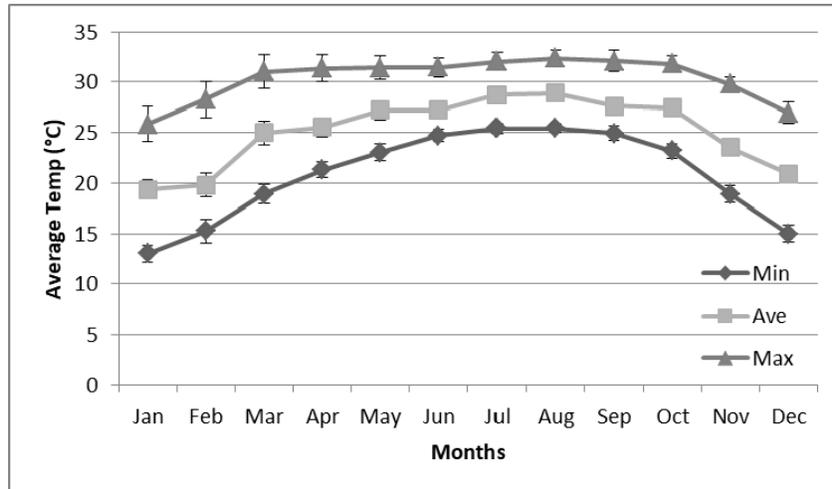


Figure 4 Average air temperature (°C) per month of Sylhet from the periods of 30 years (1988-2017). Bars represent the standard deviation (\pm)

10.1.2.3. Sunshine Duration

In Sylhet, annual average sunshine hour from the periods of 30 years (1988-2017) was 5.86 ± 0.34 hr/day. The monthly highest average sunshine hour was 7.92 ± 0.76 hr/day in November whereas the monthly lowest average sunshine hour was 3.39 ± 0.76 hr/day in June (Figure 5).

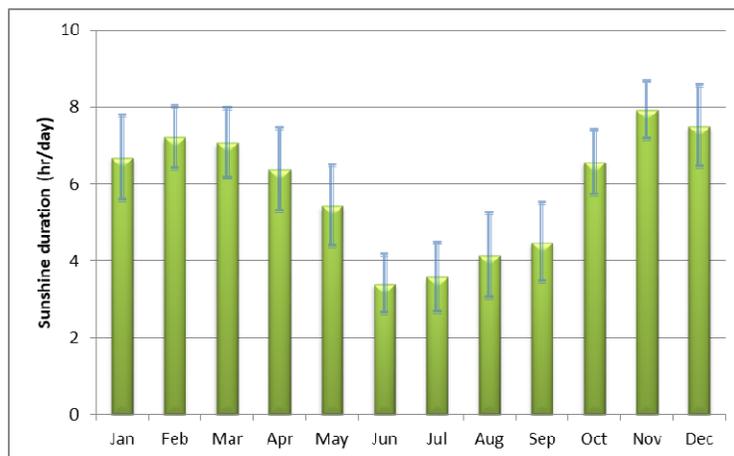


Figure 5 Average sunshine duration (hr/day) per month of Sylhet from the periods of 30 years (1988-2017). Bars represent the standard deviation (\pm)

10.2. Study 1: Document the composition & diversity of existing agroforestry practices

10.2.1. Study area

The study was conducted at Jaintiapur and Golapganj upazila of Sylhet district. Jaintiapur upazila has 6 unions namely Nijpat, Jaintiapur, Charikata, Darbast, Fatehpur and Chiknagul. Among the six, three unions (Jaintiapur, Fatehpur and Chiknagul) were selected randomly for the study. Data were collected from July to December 2017. On the otherhand, Golapganj upazila has 11 unions namely Amura, Uttor Badepasha, Golapganj, Dhaka Dakkhin, Fulbari, Bagha, Budhbari Bazar, Vadesshor, Lokkхинabondo, Lokkhipasha and Sharifganj. Among the unions of Golapganj upazila, two villages (Turupbag and Gondamara) of the Bagha union were selected randomly for the study. Data were collected from January to July 2018.

10.2.2. Population and sample

Three unions were selected randomly from Jaintiapur upazila. Farmers of these three unions constituted the population for the study. From this population, 34 farmers from each union were selected randomly as the sample for the study. Thus, the sample size became 102. On the other hand, two villages were selected randomly from Golapganj upazila. Farmers of these two villages constituted the population for the study. From this population, 30 farmers from each village were selected randomly as the sample for the study. Thus, the sample size became 60.

10.2.3. Research instrument

For conducting a study, every research method has its own instrument for data collection. Data need to be consciously identified, carefully selected, methodologically collected and accuracy and precision are obviously important quality in research measurement. In this study face to face interview method was used. In order to collect relevant information, a structured interview schedule was prepared considering the objectives of the study. The schedule contained both open, closed and multiple choice questions. Most easy, simple direct questions and different scales were used to obtain the information. Direct questions were also used to

obtain information, like age, education, farm size, and family income, training etc. The questions were arranged systematically and presented clearly so that the respondents could understand to furnish information in a consistent and systematic manner.

A pre-test survey was undertaken before the actual collection of data. This survey provided an opportunity to examine the effectiveness of the schedule which revealed some unforeseen defects associated with it. Based on the pre-test experience, necessary correction, addition, alteration, rearrangements were made. Thus the interview schedule was prepared for the final use. The interview schedule was enclosed in Appendix I.

10.2.4. Methods and procedure of data collection

Data for this study were collected through personal interview by the researcher herself during July, 2017 to July, 2018. The interview schedule prepared earlier by the researcher was used to gather information. Focus group discussion was done to validate the information. All possible efforts were made to explain the purpose of the study to the respondents in order to get valid and pertinent information from them.

Interviews were conducted with the respondents at their homes. While starting interview with any respondent, the researcher took all possible care to establish rapport with them so that they did not feel uneasy or hesitation to furnish proper responses to the questions and statements in the interview schedule. The questions were explained and clarified whenever any respondent felt difficulty in understanding properly.

10.2.5. Statistical analysis

Collected data were analyzed in accordance with the objectives of the study. Qualitative data were converted into quantitative data by means of suitable scoring technique wherever necessary. Various statistical measures such as frequency counts, percentage distribution, average, standard deviation and rank were used in describing data.

10.3. Study 2: Status of Climate-Smart Agriculture practices

Methodology of study 2 is same as study 1.



Figure 6 Personal interview conducted at Jaintiapur upazila in Sylhet district



Figure 7 Personal interview conducted at Golapgonj upazila in Sylhet district



Figure 8 Focus group discussion (FGD) conducted at Golapgonj upazila in Sylhet district

10.4. Study 3: Evaluation of agar based agroforestry practices

10.4.1. Site Selection

In order to select the site for conducting the experiment, different visits to different places were done. Finally, Barlekha upazila was selected for conducting the study. As the purpose of the study was to develop Agar based agroforestry system, it was mandatory to conduct the study in Agar planted field. There are a large number of Agar field in Barlekha Upazila, for this reason Barlekha was selected. After several visit and discussion with local people, Enainagar village was selected to set the experiment.



Figure 9 Field visit for site selection

10.4.2. Geographical location

The study was conducted in Barlekha upazila under Moulvibazar district, Bangladesh. Barlekha upazila is situated between 24°33' and 24°50' north latitude and between 92°20' and 92°18' east longitude. The upazila is bounded by Bianibazar (Sylhet) on the north, India on the east, Kulaura and Juri on the south, Golapganj and Fenchuganj (Sylhet) upazilas on the west.

10.4.3. Physiographic and Soil Condition

Bangladesh is primarily floodplains of the Ganges-Brahmaputra Jamuna-Meghna river system with only some hilly areas in the southern and northeastern parts of the country. According to the Agro-ecological Zones (AEZs) of Bangladesh, Barlekha upazila of Moulvibazar district lies in AEZ 22; Northern and Eastern Piedmont Plains (High: 33% Medium high: 31% Medium low: 16%

Others: 20%) and AEZ 29- Northern and Eastern Hills (High: 92%Others: 8%). Organic matter and Nutrient content of soil is medium.

10.4.4. Selection of Agar garden

An agar garden of 0.5 ha land having 100 agar trees with an average spacing of 1 m was selected for the experiment. The age of the trees varied from 5-6 years with unidentified varieties. The trees were not planted maintaining specific spacing, but there was enough space for growing under-story crops.

10.4.5. Establishment of Agar based agroforestry

The agar based agroforestry system was established by keeping the existing agar trees as overstory and growing associated crops as understory. The experiment was laid out in a randomized complete block design (RCBD) with three replications. At least one agar tree and its surrounding area were considered as a unit plot for a single replication.

10.4.6. Land preparation and intercultural operation

The experimental plot was first opened on 01 March 2018 by spading. Weeds and rubbishes were removed from the field. The plot preparation was completed on 5 March 2018. The recommended basal doses of fertilizers were applied and mixed into the soil during final land preparation. After transplanting, irrigation was done frequently as there was scarcity of soil moisture in the field. Irrigation was done in every 15 days interval during whole dry season for better establishment of crops. Weeding and other intercultural operation were done properly and equally to all the plots whenever it required.



Figure 10 Preparation of land and transplanting sole crop at Enainagor, Barlekha, Moulvibazar

Table 1 Plant population and plant spacing of intercrops in agar plantation

Intercrops	Row-row distance(cm)	Plant-plant distance (cm)	No of row/ plots	No of plants/row	Total plants/plots
Malta	50	40	4	5	20
Tea	50	40	4	5	20
Pineapple	50	40	4	5	20
Turmeric	50	40	4	5	20
Zinger	50	40	4	5	20
Bilati dhonia	50	40	4	5	20

10.4.7. Experimental materials

The experiment was carried out with six different demandable species, namely pineapple (*Ananas comosus*), malta (*Citrus sinensis*), ginger (*Zingiber officinale*), tea (*Camellia sinensis*), turmeric (*Curcuma longa*) and bilati dhonia (*Eryngium foetidum*), and existing agar plant (*Aquilaria malaccensis*). The plantation of agar was selected from established garden at Enainagor of Bianibazar upazila. The experiment comprises of 13 treatments combinations taking agar plant as woody perennial and associated plants as crops of agroforestry system.

10.4.8. Treatments of the study

The experiment was conducted using thirteen treatments and all the treatments had three replications. The treatments were as followings:

T1: Agar Sole

T5: Tea Sole

T9: Agar + Malta

T2: Pineapple Sole

T6: Turmeric Sole

T10: Agar + Ginger

T3: Malta Sole

T7: Bilati Dhonia Sole

T11: Agar + Tea

T4: Ginger Sole

T8: Agar + Pineapple

T12: Agar + Turmeric

T13: Agar + Bilati Dhonia

10.4.9. Experimental Design

An agar tree was considered as the center of each plot for agroforestry practice, which was compared with monocrop as control. For agar, data on growth performances before and after the experimentation were compared. In the case of different crops, data from monocrop (*e.g.*, control malta) and agroforestry plots (with agar plant) were collected for comparison between two systems. Each unit plot was replicated three times with an arrangement of RCBD. The reason of using RCBD was that it had opportunity to minimize plot errors as soil was not homogeneous across the whole field. Control plots for crops were established in fallow land in an open space near the agar garden. The size of each plot was 2m×2m. The total number of plots was thirty nine. Block to block distance and plot to plot distance was 1 m and 0.5 m, respectively. Data were collected from each plot.



Figure 11 Experimental plots of agar based agroforestry



Figure 12 Experimental plots of sole crops

10.4.10. Duration of the Study

The study was conducted from February 2018 – September 2018. The site selection and land preparation was done in February 2018. Initial data was measured during plantation of crops.

10.4.11. Data collection

In order to measure the growth of different plants, different parameters were considered for collecting data. These are given below:

Table 2 Parameters of plants for data collection

Plant species	Parameters
Agar (<i>Aquilaria malaccensis</i>)	Plant height (m), DBH (cm), Girth at base, middle and collar.
Tea (<i>Camellia sinensis</i>)	Plant height (cm), no. of branches, no. of leaves, stem diameter (mm) at 15 cm height, canopy at N-S and E-W (cm).
Malta (<i>Citrus sinensis</i>)	Plant height (cm), no. of branches, no. of leaves, Stem diameter (mm), and canopy at N-S & E-W (cm).
Pineapple (<i>Ananas comosus</i>)	No. of leaves, canopy at N-S & E-W (cm).
Ginger (<i>Zingiber officinale</i>)	No. of leaves, plant height (cm), canopy at N-S & E-W (cm), Weight of rhizome, number of rhizome per plot, number of finger per plot.
Turmeric (<i>Curcuma longa</i>)	No. of leaves, plant height (cm), canopy at N-S & E-W(cm) Weight of rhizome, number of rhizome per plot, number of finger per plot.
Bilati dhonia (<i>Eryngium foetidum</i>)	No. of leaves, Root weight, Shoot weight(gm).

Data were collected by the measuring tap, slide calipers etc. Initially data were recorded by pencil and paper but after returning from field the data were put in Microsoft Excel sheet regularly.



Fig. 13.1. collecting data on growth parameters of Tea



Fig. 13.2. collecting data on growth parameters of Turmeric



Fig. 13.3. collecting data on growth parameters of Agar



Fig. 13.4. Harvesting sole turmeric sole



Fig. 13.5. Harvesting zinger under agroforestry system



Fig. 13.6. Measuring yield of zinger



Fig. 13.7. Harvested turmeric



Fig. 13.8. Harvested zinger



Fig. 13.9. Harvested bilati dhonia

Figure 13. Pictorial view of data collection on growth and yield parameters of agar plants and associated crops

10.4.12. Collection of soil sample and analysis

Soil samples were collected from individual plot during transplanting and at the end of the project following random sampling technique. Then collected soil samples were sent to SRDI in Sylhet for analyzing pH, total N (%), OM (%), K (meq/100g), Ca (meq/100g), Mg (meq/100g), P (ug/g soil), S (ug/g soil), B (ug/g soil), Zn (ug/g soil), Cu (ug/g soil), Fe (ug/g soil), Mn (ug/g soil).

10.4.13. Data Analysis

The data were statistically analyzed using analysis of variance (ANOVA) with the help of R version 3.4.3 to find out significant variation among treatments. The mean differences were determined by least significant difference (LSD) at 5% level of significance.



Figure 14 Analysis of soil at SRDI, Sylhet

11. Results and discussion

11.1. Study 1: Document the composition & diversity of existing agroforestry practices

11.1.1. At Gopalganj upazila

The findings and discussions were presented in this chapter according to the objectives of the study. The findings were however discussed under the following sections:

11.1.1.1. Selected socio-economic characteristics of the farmers

Data were collected for fourteen socio-economic characteristics of the respondents. A summary of the analyzed result for the selected socio-economic characteristics of the farmers is shown in table 3.

Table 3 Salient features of the selected Socio-economic characteristics of the farmers

Characteristics	Unit of measurement	Observed range	Mean	Standard deviation
Age	Year	20-75	45.02	14.33
Education level	Year of schooling			
		0-16	5.42	3.82
Family size	Number	2-21	6.86	3.33
Farm size	Acre	0-4.5	2.11	4.18
Annual family income	Thousand Tk.	24-1080.00	272.1	293.07
Credit received	Dummy			
Remittance received	Dummy			
Agricultural training	Dummy			
Extension contact	Dummy			
Involvement in a society/ organization	Dummy			
Land topography	Dummy			
Erosion hazard	Dummy			
Distance to local market				
	Km	0.5-5.00	1.98	0.67
Distance to road	Km	0.5-3.00	0.76	0.58

11.1.1.1.1. Age

On the basis of National Youth policy, respondents were classified into three categories namely Young (18 - 35 years), Middle aged (36 - 50 years) and Old (above 50 years). The observed age of the respondents ranged from 20 to 70 years with the mean being 45.02 and the standard deviation was 14.33. Distribution of the farmers according to their age is shown in table 4.

Table 4 Distribution of the farmers according to age

Categories (Years)	Number	Percent	Mean	SD
Young aged (18-35)	14	23.33		
Middle aged (36-50)	24	40.00	45.02	14.33
Old aged (above 50)	22	36.67		
Total	60	100		

11.1.1.1.2. Education level

Education level of the respondents were classified into four categories namely Illiterate (0), Primary (1-5), Secondary (6-10) and Higher studies and above (11 & above) considering their year of schooling. The education level of the respondents ranged from 0 to honors with the mean of 5.42 and the standard deviation was 3.82. Distribution of the farmers according to their education level is shown in the table 5.

Table 5 Distribution of the farmers according to education level

Education level (Schooling years)	Number	Percent	Mean	Standard deviation
Illiterate (0)	10	16.67		
Primary (1-5)	25	41.67	5.42	3.82
Secondary (6-10)	22	36.67		
Higher studies (11&above)	3	5.00		
Total	60	100		

11.1.1.1.3. Family size

The respondents were classified into three categories namely Small family (<5), Medium family (5-8) and Large family (>8). Family size of the respondents varied from 2 to 21 with the mean of 6.86 and standard deviation was 3.33. Distribution of the farmers according to their family size is shown in the table 6.

Table 6 Distribution of the farmers according to family size

Categories (Number)	Number	Percent	Mean	Standard deviation
Small family (<5)	15	25		
Medium family (5-8)	23	38.33	6.86	3.33
Large family (>8)	22	36.67		
Total	60	100		

11.1.1.1.4. Farm size

On the basis of the respondent's total farm size they were classified into four categories namely landless & marginal (<0.21 hectare), small (0.21-1.0 hectare), medium (1.1-3.0 hectare) and large (>3.0 hectare). The farm size of the respondents ranged from 0 to 8.3 hectares with the mean of 15.5 and the standard deviation was 4.39. Distribution of the farmers according to their farm size is shown in table 7.

Table 7 Distribution of the farmers according to farm size

Categories (acre)	Number	Percent	Mean	Standard deviation
Landless & marginal (<0.21)	12	20.0		
Small (0.21-1.0)	17	28.3		
Medium (1.1-3.0)	21	35	2.11	4.18
Large (>3.0)	10	16.6		
Total	60	100		

11.1.1.1.5. Annual family income

Family income of the respondents ranged from BDT 24000 to 1440000 with a mean of 20 and standard deviation of 5.72. Based on their family income, the respondents were classified into three categories: low income (up to Tk. 100,000), medium income (Tk. 101,000 to 200,000) and high income (above Tk. 201,000). Distribution of the farmers according to their annual family income is shown in table 8.

Table 8 Distribution of the farmers according to annual family income

Categories (Thousand"000" TK.)	Number	Percent	Mean	Standard deviation
Low income (Up to 100)	20	33.33		
Medium income (101-200)	13	21.67	272.1	293.07
High income (above 201)	27	45.00		
Total	60	100		

11.1.1.1.6. Credit received

Respondents were classified into two categories as credit received & not received. Results showed 0 percent of the respondents had received credit and 100 percent hadn't received any credit. Distribution of the farmers according to credit received is shown in table 9.

Table 9 Distribution of the farmers according to agricultural credit received

Categories (Dummy)	Number	Percent
Received(1)	0	0
Not Received(0)	60	100
Total	60	100

11.1.1.1.7. Remittance received

Respondents were classified into two categories as remittance received & not received. Most of the farmers do not receive remittance. Distribution of the farmers according to remittance received is shown in table 10.

Table 10 Distribution of the farmers according to remittance received

Categories (Dummy)	Number	Percent
Received(1)	16	26.67
Not Received(0)	44	73.33
Total	60	100

11.1.1.1.8. Agricultural training

Respondents were classified into two categories as training received & not received. A good number of farmers have experiences of training. Distribution of the farmers according to training received is shown in table 11.

Table 11 Distribution of the farmers according to agricultural training experience

Categories (Dummy)	Number	Percent
Received(1)	33	55.00
Not Received(0)	27	45.00
Total	60	100

11.1.1.1.9. Involvement in a society/organization

Respondents were classified into two categories as involved & not involved in a society/organization. Distribution of the farmers according to their involvement in a society/organization is shown in table 12.

Table 12 Distribution of the farmers according to involvement in a society or organization

Categories (Dummy)	Number	Percent
Involved(1)	29	48.33
Not Involved (0)	31	51.67
Total	60	100

11.1.1.1.10. Land topography

In the study area both plain and slope land topography was found. Distribution of the farmers according to land topography is shown in table 13.

Table 13 Distribution of the farmers according to land topography

Categories (Dummy)	Frequency	Percent
Plain(1)	46	76.6
Slope(2)	5	8.3
Both(3)	9	15
Total	60	100

11.1.1.1.11. Erosion hazard

Respondents were classified into two categories as erosion hazard found & not found in their field. Erosion hazard is less in this area according to the opinion of the farmers. Distribution of the farmers according to erosion hazard found is shown in table 14.

Table 14 Distribution of the farmers according to agricultural erosion hazards

Categories (Dummy)	Number	Percent
Found(1)	4	6.7
Not found(0)	56	93.3
Total	60	100

11.1.1.1.12. Distance from home to local market

Distance from home to local market of the respondents was classified into three categories as little, moderate, and high. Distance from home to local market of the respondents ranged from 0.05 to 6.0 k.m with a mean of 1.98 k.m. and standard deviation of 0.67 (Table 15)

Table 15 Distribution of the farmers according to distance from home to local market

Categories(Km)	Number	percent	Mean	Standard deviation
Little(<1)	6	10		
Moderate(1-2)	12	20	1.98	0.67
High(>2)	42	70		
Total	60	100		

11.1.1.1.13. Distance from home to road

Distance from home to road of the respondents was classified into three categories as little, moderate, and high. Distance from home to road of the respondents ranged from 0.01 to 3.00 with a mean of 0.82 and standard deviation of 0.72. Distribution of the farmers according to distance from home to road is shown in table 16.

Table 16 Distribution of the farmers according to distance from home to road

Categories(Km)	Number	Percent	Mean	Standard deviation
Near (<1)	53	88.3		
Moderate(1-2)	4	6.7	0.76	0.58
Far (>2)	3	5		
Total	60	100		

11.1.1.2. Farmers' involvement in production activities

Farmers were involved in different production activities *viz.* homestead agroforestry, livestock, field crop production, roadside agroforestry, citrus based agroforestry, aquaforestry, pineapple based agroforestry, cropland agroforestry, betel leaf agroforestry , black pepper based agroforestry, drumstick production, apiculture, agar plantation and others production practices. Among the production activities most of the respondents were involved in rice cultivation, guava cultivation, vegetables cultivation, supari cultivation, livestock (cattle, pasture, poultry, turkey, titir) etc. But here berry, toikor, satkora are neglected and underutilized species which have a huge research scope as Sylhet district is good for citrus cultivation. Distribution of the farmers depending on their involvement in production activities is shown in figure 15.

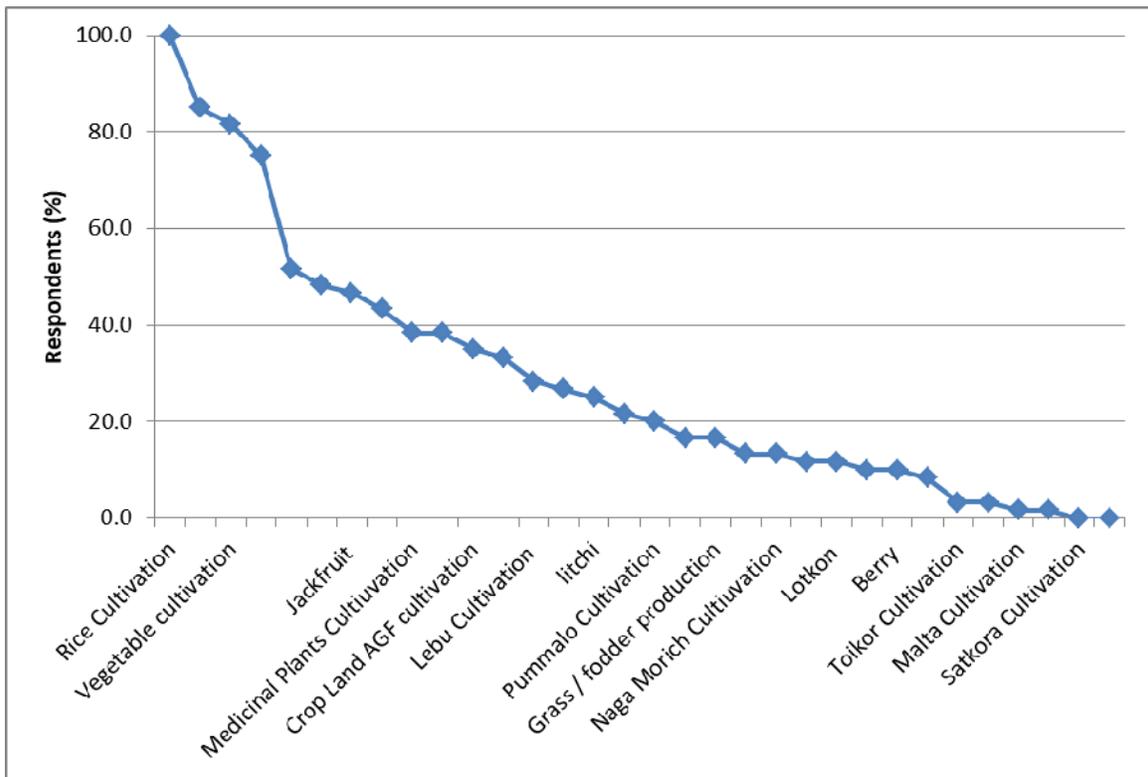


Figure 15 Distribution of the farmers depending on their involvement in production activities in Golapgonj upazilla of sylhet district during 2018.

11.1.1.3. Source of propagation materials

In the study area it was reported that farmers collect propagation materials from different sources viz. seed bank, seed producers, own production, neighbors, dealer, local market, and others. Most of the farmers collect seed from local market. Distribution of the farmers according to their sources of propagation material is shown in figure 16.

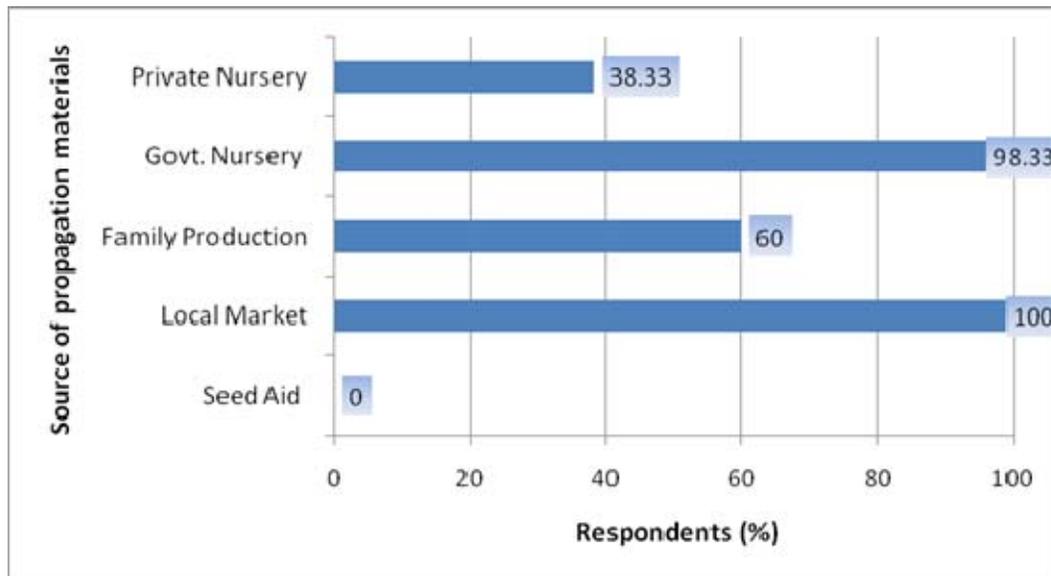


Figure 16 Distribution of the farmers depending on their source of propagation materials for crop production.

11.1.1.4. Traditional management practices

In the study area farmers apply different traditional management practices in tree and crop production viz. fertilization, mulching, irrigation, drainage, staking, training, pruning, weeding and pesticide application. It can be said that all farmers apply fertilizer and do weeding. In case of crop, they practice mulching at a low rate. This practice can be done in a high rate. Distribution of the farmers according to the management practices they apply in crop production and tree production are shown in figure 17 and 18, respectively.

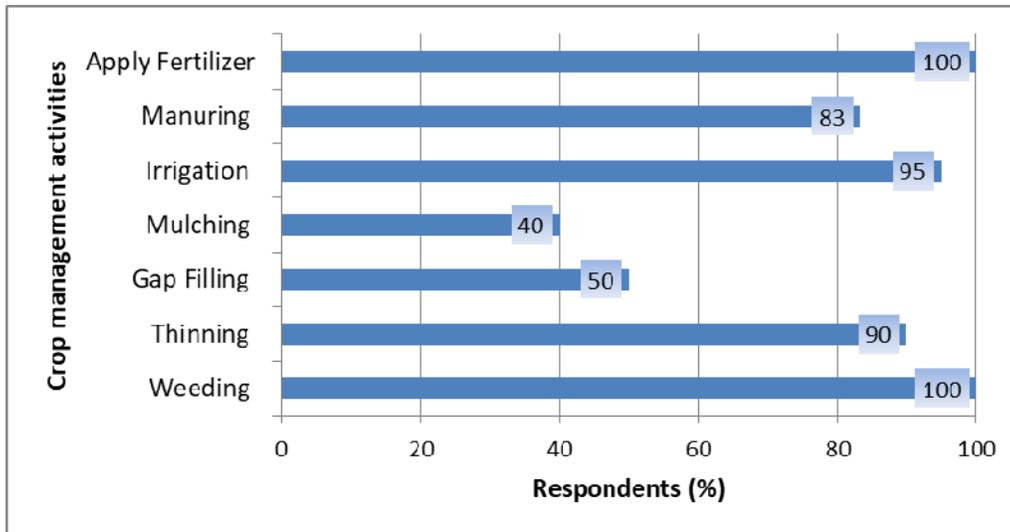


Figure 17 Distribution of the farmers depending on their list of crop management

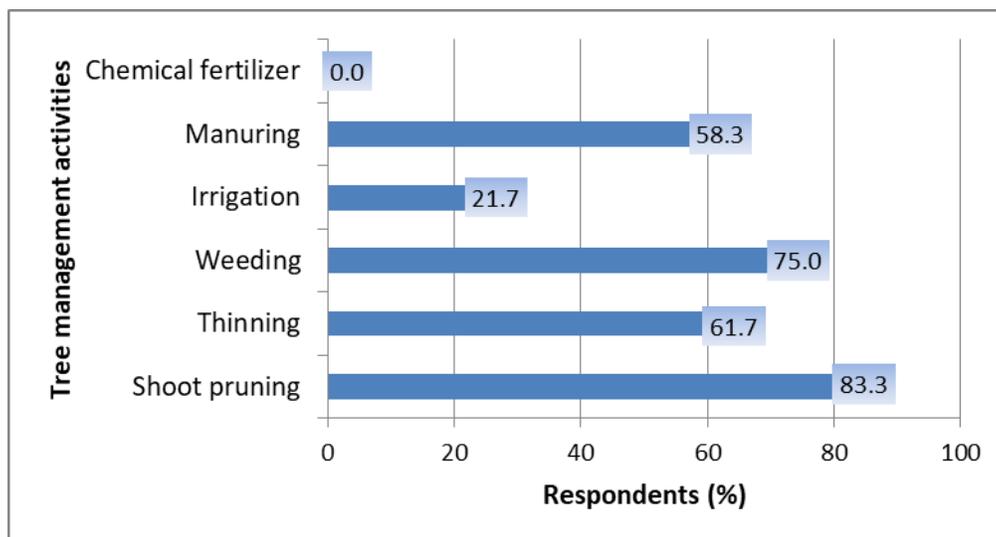


Figure 18 Distribution of the farmers depending on their involvement in tree management activities.

11.1.1.5. Plant species diversity

Diversified plant species were observed in the study area. Total 86 plant species were recorded from the survey area of which 38 were homestead species, 29 were vegetable species, 12 were medicinal species, and 7 were spice species. Diversity of plant species in Golapgonj upazilla was high which ranged from 0.83 to 0.94 and average was 0.88. Among the plant species vegetable species diversity was much higher than the diversity of the other plant species, though there was no significant difference among the different species. The relative abundance of existing

plant species was fruit species> vegetable species> medicinal species> spice species (44.19%> 33.72%> 13.95%> 8.14%). Besides this some new crop and tree species are being cultivated in the study area such as HYV tomato, sweet gourd, mangium, guava etc. Distribution of the farmers according to homestead, vegetable, medicinal, spice and newly planted crop and tree species they cultivate are shown in table.

11.1.1.5.1. Distribution of the farmers according to homestead species they cultivate

Among homestead species the dominant species was jackfruit (85%) followed by banana (66.67%), coconut (61.67%), ber (59%), hogplam (45%), guava, papaya, mango (41.72% each).

Table 17 Distribution of the farmers according to homestead species they cultivate

Species	Scientific Name	Frequency	%	RA%
Jackfruit	<i>Artocarpus heterophylus</i>	51	85.00	9.62
Banana	<i>Musa paradiscum</i>	40	66.67	7.55
Coconut	<i>Cocos Nucifera</i>	37	61.67	6.98
Jujubi	<i>Zizpus mauritania</i>	30	50.00	5.66
Amra	<i>Spondias pinnata</i>	27	45.00	5.09
Guava	<i>Psidium guava</i>	25	41.67	4.72
papaya	<i>Carica papaya</i>	25	41.67	4.72
Mango	<i>Mangifera indica</i>	25	41.67	4.72
Litchi	<i>Litchi chinensis</i>	23	38.33	4.34
Dayfol	<i>Garcinia xanthochymus</i>	21	35.00	3.96
Betel nut	<i>Areca catechu</i>	18	30.00	3.40
Mengium	<i>Acacia mangium</i>	17	28.33	3.21
Acacia	<i>Acacia auriculiformis</i>	14	23.33	2.64
Adalebu	<i>Citrus limon</i>	14	23.33	2.64
Tamarind	<i>Tamarindus indica</i>	13	21.67	2.45
Orange	<i>Citrus aurentium</i>	11	18.33	2.08
Olive	<i>Elaeocarpus floribundus</i>	11	18.33	2.08
Korun jamin	Local sp.	11	18.33	2.08
Lotkon	<i>Baccaurea motleyana</i>	11	18.33	2.08
Deuya	<i>Artocarpus lacucha</i>	9	15.00	1.70
Lemon	<i>Citrus limon</i>	8	13.33	1.51
Jara lebu	<i>Citrus limon</i>	8	13.33	1.51
Pineapple	<i>Ananas comosus</i>	7	11.67	1.32
Black berry	<i>Syzygium cumini</i>	7	11.67	1.32
Gab	<i>Diospyros discolor</i>	7	11.67	1.32
Kamranga	<i>Averrhoa carambola</i>	6	10.00	1.13
Sugar Cane	<i>Saccharum officinarum</i>	5	8.33	0.94

Species	Scientific Name	Frequency	%	RA%
Ata	<i>Annona squamosa</i>	5	8.33	0.94
Palm	<i>Serenoa repens</i>	4	6.67	0.75
Cham Kathal	<i>Artocarpus chama Buch-Ham</i>	3	5.00	0.57
Date	<i>Phoenix dactylifera</i>	3	5.00	0.57
Chalta	<i>Dellenia indica</i>	2	3.33	0.38
Amla	<i>Phyllanthus emblica</i>	2	3.33	0.38
Kau	Local sp.	2	3.33	0.38
Kata lebu	Local sp.	1	1.67	0.19
Wood apple	<i>Aegle marmelos</i>	5	8.33	0.94
Lukluki	<i>Flacourtia jangomes</i>	3	5.00	0.57

11.1.1.5.2 Distribution of the farmers according to vegetable species they cultivate

Among vegetable, the dominant was country bean (68.33%) followed by sweet gourd (58.33%), tomato (46.67%) bottol gourd (46.67%), ridge gourd (43.33%), radish (41.67%), yard long bean and red amaranth (40% each).

Table 18 Distribution of the farmers according to vegetable species they cultivate

Species	Scientific Name	Frequency	%	RA%
Bean	<i>Lablab purpureus</i>	41	68.33	8.82
Sweet gourd	<i>Cucurbita maxima</i>	35	58.33	7.53
Tomato	<i>Lycopersicon esculentum</i>	28	46.67	6.02
Bottle gourd	<i>Lagenaria siceraria</i>	28	46.67	6.02
Ridge gourd	<i>Luffa acutangula</i>	26	43.33	5.59
Raddish	<i>Raphanus sativus</i>	25	41.67	5.38
Yard long bean	<i>Vigna sesquipedalis</i>	24	40.00	5.16
Red amaranth	<i>Amaranthus cruentus</i>	24	40.00	5.16
Brinjal	<i>Solanum melongena</i>	22	36.67	4.73
Amaranth	<i>Amaranthus lividus</i>	22	36.67	4.73
Cucumber	<i>Cucumis sativas</i>	20	33.33	4.30
Potato	<i>Solanum tuberosum</i>	18	30.00	3.87
Sponge gourd	<i>Luffa cylindrica</i>	18	30.00	3.87
Bitter gourd	<i>Momordica charantia</i>	15	25.00	3.23
Jute leaf	<i>Corchorus olitorius</i>	13	21.67	2.80
French Bean	<i>Phaseolus vulgaris</i>	13	21.67	2.80
Mukhi Kachu	<i>Colocasia antiquorum</i>	12	20.00	2.58
Rai shak	<i>Brassica campestris</i>	11	18.33	2.37
Chal Kumra	<i>Benincasa hispida</i>	10	16.67	2.15

Species	Scientific Name	Frequency	%	RA%
Snake Gourd	<i>Trichosanthes cucumerina</i>	10	16.67	2.15
Khira	<i>Cucumis sativus</i>	9	15.00	1.94
Spinach	<i>Basella alba</i>	9	15.00	1.94
Cabbage	<i>Brassica oleracea var. capitata</i>	8	13.33	1.72
Ladys Finger	<i>Abelmoschus esculentus</i>	7	11.67	1.51
Unripen banana	<i>Musa balbisiana</i>	6	10.00	1.29
Cauliflower	<i>Brassica oleracea var. botrytis</i>	5	8.33	1.08
Broccoli	<i>Brassica oleracea var. italica</i>	2	3.33	0.43
Capsicum	<i>Capsicum annuum</i>	2	3.33	0.43
Sweet Potato	<i>Ipomoea batatas</i>	2	3.33	0.43

11.1.1.5.3. Distribution of the farmers according to medicinal species they cultivate

Among medicinal species the dominant species is neem (41.67%) followed by khude thankuni (36.67%), haritoki (25%), tulsi and chengpichuli (15% each).

Table 19 Distribution of the farmers according to medicinal species they cultivate

Species	Scientific Name	Frequency	%	RA %
Neem	<i>Azadirachta indica</i>	25.00	41.67	25.00
Khude Thankuni	<i>Centella asiatica</i>	22.00	36.67	22.00
Haritaki	<i>Terminalia chebula</i>	15.00	25.00	15.00
Tulsi	<i>Ocimum sanctum</i>	9.00	15.00	9.00
Chengpichoil	Local sp.	9.00	15.00	9.00
Arjun	<i>Terminalia arjuna</i>	8.00	13.33	8.00
Basok	<i>Adhatoda vasica</i>	4.00	6.67	4.00
Lozaboti	<i>Mimosa pudica</i>	3.00	5.00	3.00
Amla	<i>Phyllanthus emblica</i>	2.00	3.33	2.00
eola	Local sp.	1.00	1.67	1.00
Pathorkuchi	<i>Bryophyllum pinnatum</i>	1.00	1.67	1.00
Longevity Spinach	<i>Gynura procumbens</i>	1.00	1.67	1.00

11.1.1.5.4. Distribution of the farmers according to spice species they cultivate

Among spice species bay leaf (51.67%) is the dominant species followed by green chilli (50.00%), nagamorich (41.67%), coriander leaf (38.33%), elachi and ginger (15% each).

Table 20 Distribution of the farmers according to spice species they cultivate

Species	Scientific Name	Frequency	%	RA%
Bayleaf	<i>Cinnamomum tamala</i>	31.00	51.67	24.80
Green Chilli	<i>Capsicum frutescens</i>	30.00	50.00	24.00
Naga Morich	<i>Capsicum chinense</i>	25.00	41.67	20.00
Coreander leaf	<i>Coriandrum sativum</i>	23.00	38.33	18.40
Elachi	<i>Elettaria cardamomum</i>	9.00	15.00	7.20
Ginger	<i>Zingiber officinale</i>	9.00	15.00	7.20
Turmaric	<i>Curcuma longa</i>	4.00	6.67	3.20

11.1.1.5.5. Distribution of the farmers according to newly planted species

In the study area it was found that the cultivation of 29 plant species has increased.

11.1.1.5.5.1. Distribution of the farmers according to newly planted crop species

In the study area it was found that the cultivation of 15 crop species has increased. Among these crops HYV tomato, sweet gourd, French bean were cultivated mostly. Distribution of the farmers according to newly planted crop species is shown in table 21.

Table 21 Distribution of the farmers according to newly planted crop species

Species	Scientific Name	Frequency	%	RA %
HYV Tomato	<i>Lycopersicon esculentum</i>	49	81.67	24.75
Sweet gourd	<i>Cucurbita maxima</i>	30	50.00	15.15
French bean	<i>Phaseolus vulgaris</i>	27	45.00	13.64
HYV Ridge gourd	<i>Luffa acutangula</i>	14	23.33	7.07
HYV Cucumber	<i>Cucumis sativas</i>	14	23.33	7.07
Khira	<i>Cucumis sativus</i>	14	23.33	7.07
Goyalgadda shim	Local sp.	13	21.67	6.57
Dimond Potato	<i>Solanum tuberosum</i>	11	18.33	5.56
Gourd	<i>Lagenaria siceraria</i>	8	13.33	4.04
HYV Okra	<i>Abelmoschus esculentus</i>	5	8.33	2.53
Capsicum	<i>Capsicum annum</i>	3	5.00	1.52
Broccoli	<i>Brassica oleracea var. italica</i>	3	5.00	1.52
BT Brinjal	<i>Solanum melongena</i>	3	5.00	1.52
Kucha	Local sp.	2	3.33	1.01
Cabbage	<i>Brassica oleracia var. capitata</i>	2	3.33	1.01

11.1.1.5.5.2. Distribution of the farmers according to newly planted tree species

It was found that the cultivation of 14 tree species has increased in the study area. Among them mengium, guava, betel nut were planted mostly. Distribution of the farmers according to newly planted tree species is shown in table 22.

Table 22 Distribution of the farmers according to newly planted tree species

Species	Scientific Name	Frequency	%	RA %
Mengium	<i>Acacia mangium</i>	51	85.00	18.28
Guava	<i>Psidium guava</i>	40	66.67	14.34
Betel nut	<i>Areca catechu</i>	38	63.33	13.62
Eucalyptus	<i>Eucalyptus globulus</i>	14	23.33	5.02
Lambu	Local sp.	14	23.33	5.02
Mehogoni	<i>Swietenia macrophylla</i>	13	21.67	4.66
Jackfruit	<i>Artocarpus heterophylys</i>	25	41.67	8.96
Jujubi	<i>Zizpus mauritania</i>	17	28.33	6.09
Kodom	<i>Neolamarckia cadamba</i>	14	23.33	5.02
Litchi	<i>Litchi chinensis</i>	3	5.00	1.08
Raintree	<i>Samanea saman</i>	8	13.33	2.87
Coconut	<i>Cocos Nucifera</i>	18	30.00	6.45
Acacia	<i>Acacia auriculiformis</i>	6	10.00	2.15
Mango	<i>Mangifera indica</i>	18	30.00	6.45

11.1.1.6. SWDI of different agroforestry practices

Shannon-Weaver Diversity Index (H') The Shannon-Weaver Diversity Index (H') was used to measure the existing plant species diversity in the study area. The H' is the direct method of determining the diversity among the plant species. The H' ranges from 0 to 1, where 1 indicates the maximum diversity. The higher the diversity index, the more is the diverse the population.

Table 23 SWDI of different plant species grown in Golapgonj upazilla

Cultivation Practices	SWDI	RA%
Homestead species	0.86	44.19
Medicinal species	0.83	13.95
Vegetable species	0.94	33.72
Spice species	0.87	8.14

11.1.1.7. Existing agroforestry practices

There are some agroforestry practices found in the study area. Distribution of the farmers depending on existing agroforestry practices are given below with bar diagram (Figure 19).

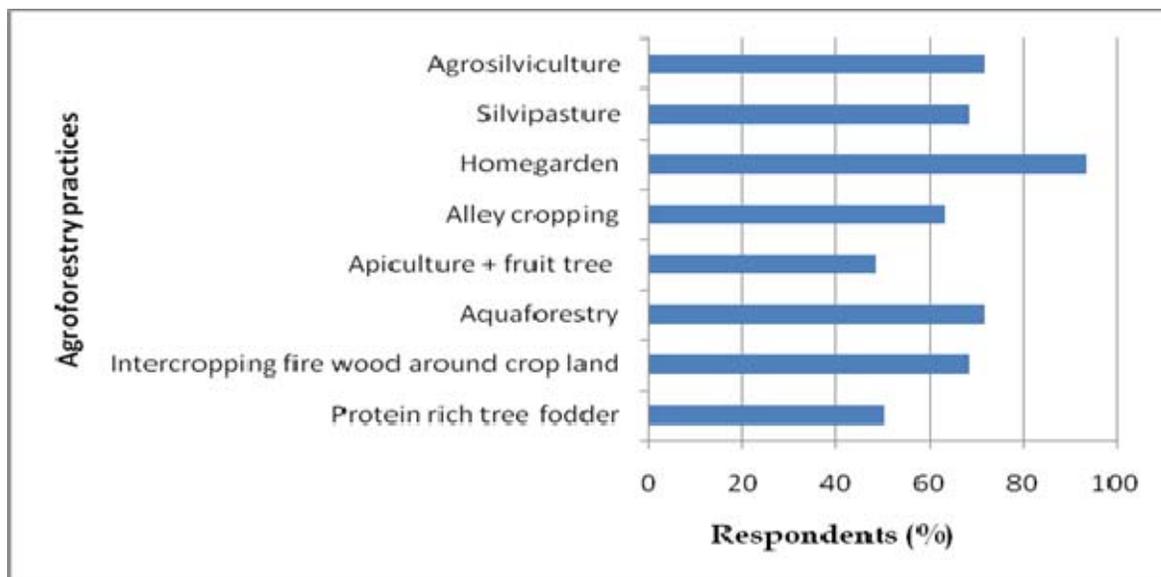


Figure 19 Distribution of the farmers depending on existing agroforestry practices

11.1.1.8. Existing agroforestry crop combination

Sl. No.	Existing agroforestry practices	Frequency	%
1	Guava – Papaya – Tomato – Neem	22	37
2	Betel nut-Country bean-Cauliflower	17	28
3	Mango-Banana-French bean	11	18
4	Coconut-Betel nut-Cabbage	10	17
5	Jackfruit – Mango – Broccoli –Capsicum	8	13
6	Tamarind- Olive- Pineapple – Bottle gourd	6	10
7	Acacia-Brinjal-Haritoki	5	8
8	Arjun-Potato – Raddish - Adalebu	5	8
9	Golmorich-Jackfruit-Sweet potato	5	8
10	Banana-Hogpalm-Titir	4	7
11	Jackfruit –Litchi – Lotcon – Satkora	4	7
12	Chamkathal-Ladies finger-Puishak	3	5
13	Mango – Cattle – Ber	3	5
14	Aquaforestry- Palm – Betelnut	3	5
15	Coconut – Bottle gourd – Titir	3	5
16	Sugarcane-Mangium-Olive	2	3
17	Wood apple-Katalebu-Amaranth	2	3

Sl. No.	Existing agroforestry practices	Frequency	%
18	Jackfruit – Cucumber – Turkey	2	3
19	Guava –Orange – Jaralebu – Gab	2	3
20	Apiculture – Ber- Blackberry- khude thankuni	2	3
21	Neem – Korunjamin – Brinjal - Tulsi	2	3

11.1.1.9. Benefits of agroforestry

The International Centre for Research in Agroforestry - ICRAF (2013) defines agroforestry as an agricultural system that integrates trees, shrubs and animals in a farm that results to multiple benefits. The respondents were provided with a 5 point likert scale to rate agroforestry's contributions towards improvement of their livelihoods.

5 points are described as:

- 5= strongly agree,
- 4=agree,
- 3=not sure,
- 2=not agree and
- 1= not agree at all

Here, some characters of benefits were taken for the farmers' perception. These are given below-

- Increasing production
- Improve microclimate
- Reduce chemical fertilizer
- Reduce crop loss
- Reduce weed infestation

Farmers gave their opinion about the above parameters of benefits. Data presentation is given below according to their perception.

11.1.1.9.1. Increasing production: About 56.67 % of the farmers were agreed in this point that this practices increase production. But a few farmers who were used to do monocropping were not much interested in it (Figure 20).

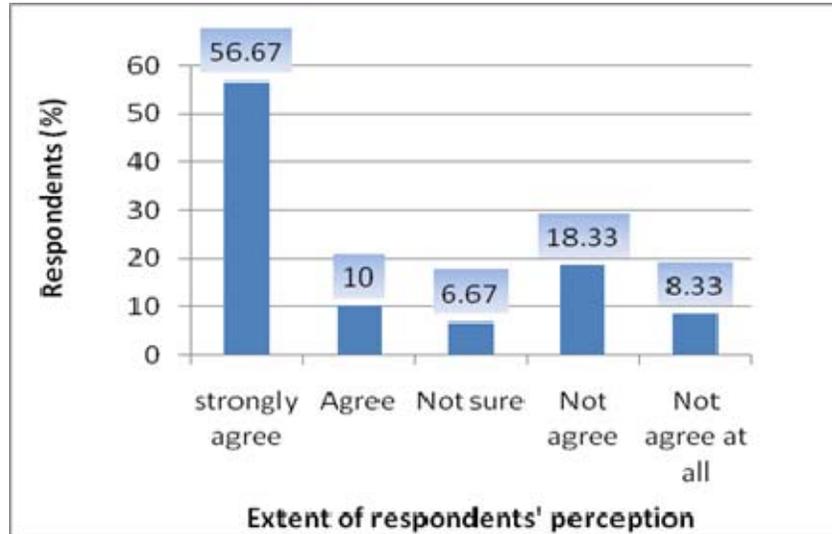


Figure 20 Farmers' perception on agroforestry practices towards increasing production

11.1.1.9.2. Improving microclimate: Some farmers were not familiar about microclimate. But most of them were strongly agreed in this regard that agroforestry practices improve microclimate in a satisfactory rate (Figure 21).

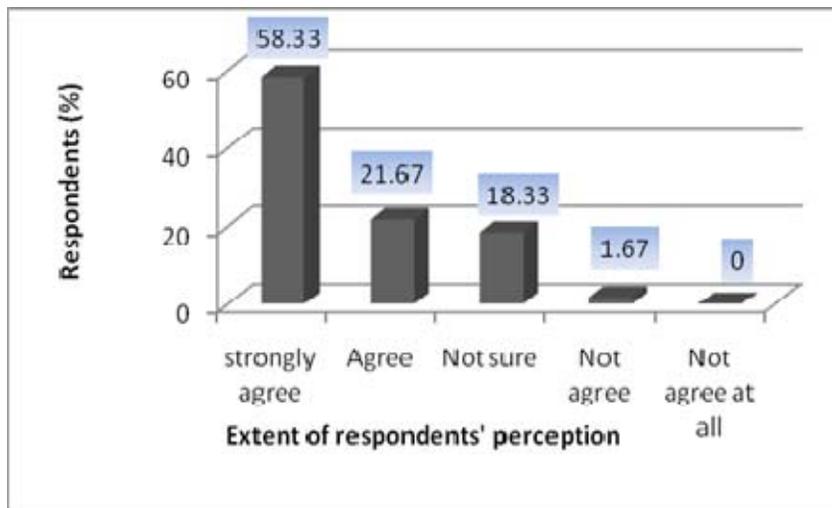


Figure 21 Farmers' perception regarding improving microclimate

11.1.1.9.3. Reducing chemical fertilizer: We all know agroforestry system has a great impact on soil fertility. This system provides best utilization of soil nutrients. Tree residues also play a significant role in manuring as well as reducing the use of chemical fertilizer. Most of the farmers (43.33%) opined this too. But 33.33 percent have dependence on chemical fertilizer and they rely on it and so they do not think agroforestry practices can reduce chemical fertilizer use (Figure 22).

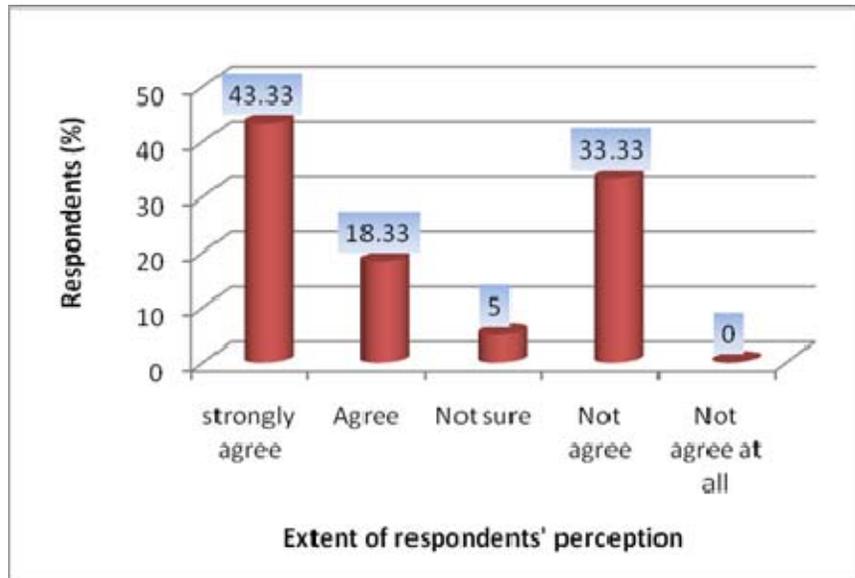


Figure 22 Farmers' perception regarding reducing chemical fertilizer

11.1.1.9.4. Reducing crop loss: Most of the farmers (46.67%) were agreed in the point that agroforestry practices reduce crop loss because if one crop is failed another crop remains ready to check the loss (Figure 23).

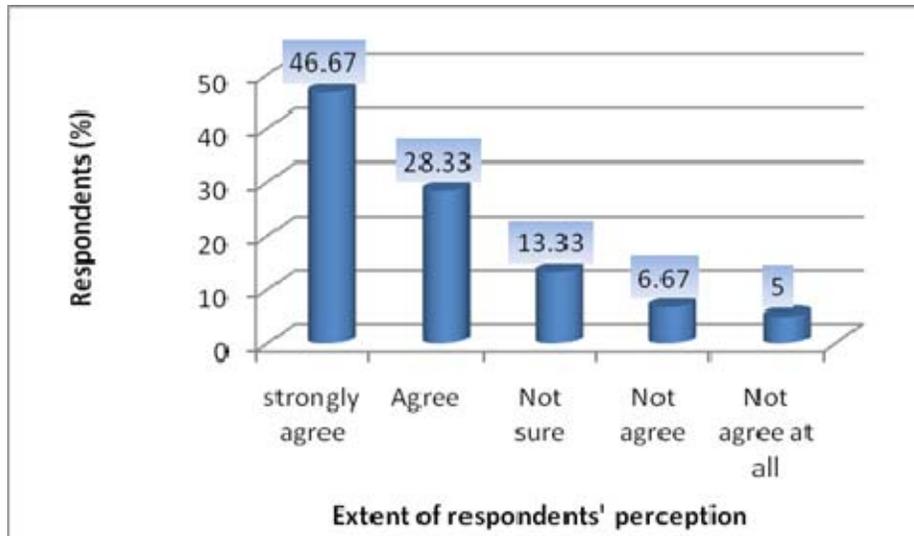


Figure 23 Farmers' perception regarding reducing crop loss

11.1.1.9.5. Reducing weed infestation: About forty two percent respondents were strongly agreed that agroforestry practices reduce weed infestation. Twenty three percent were agreed on it. But 25% were not agreed about it. Only 1.67% was not agreed at all and the rest have no idea about it (Fig. 24).

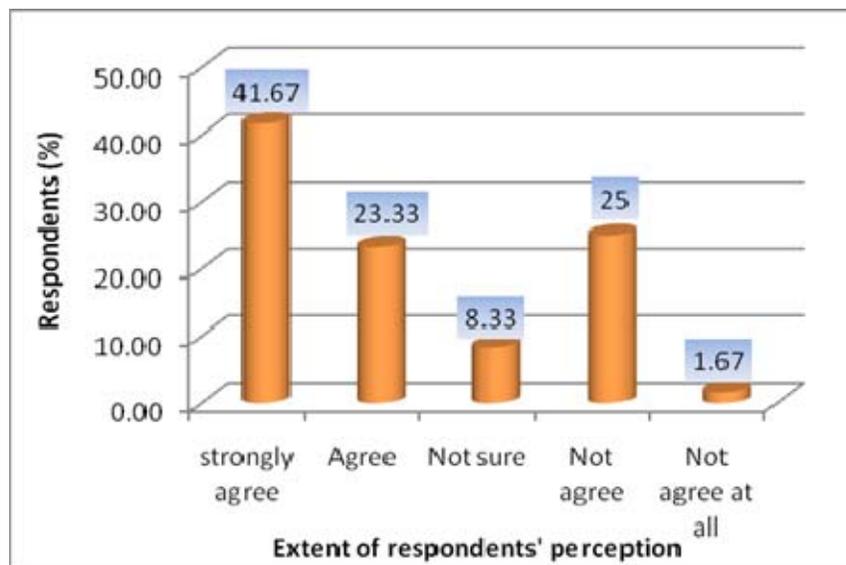


Figure 24 Farmers' perception regarding reducing weed infestation

11.1.1.10. Disadvantages of agroforestry practices

The main obstacles preventing increased agroforestry adoption included insufficient agroforestry extension, inappropriate project design or management (such as top-down management approaches, and the use of food incentives), smallholders' economic constraints, and larger policy issues. Recommendations are proposed to improve project design and management, and to address the economic and policy constraints (Fischer and Vasseur 2002)

Here, the respondents opined about disadvantages of agroforestry practices based on the following points-

- Increasing competition
- Problems in management
- Pruning material harms crop

11.1.1.10.1. Increasing Competition: Among the respondents 40% of the respondents strongly agreed and 31.67% were agreed with that this practice crop competition is increased (Figure 25).

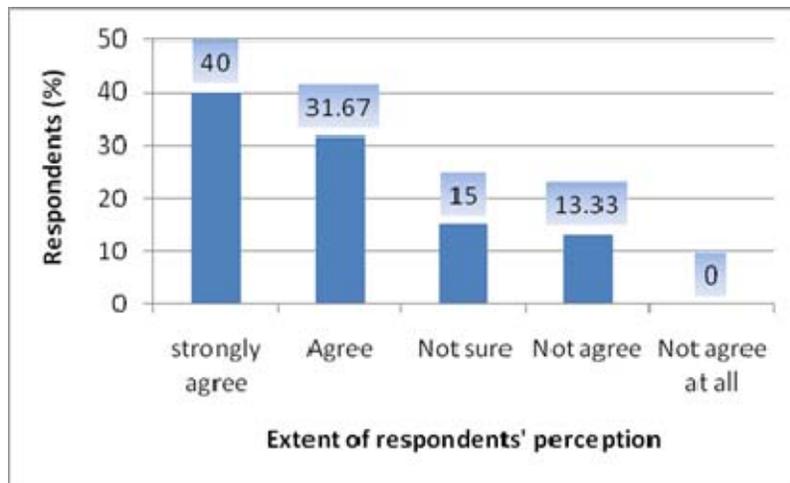


Figure 25 Farmers' perception regarding increasing competition

11.1.1.10.2. Problems in management: Most of the farmers (38.33%) were strongly agreed and 33.33% were agreed in this point that there are problems in management in agroforestry practices (Figure 26).

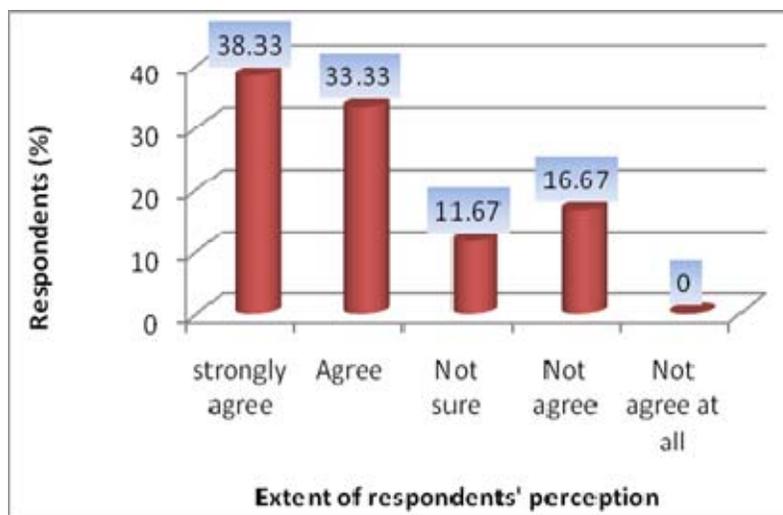


Figure 26 Farmers' perception regarding problems in management

11.1.1.10.3. Pruning material Harms Crop: Forty five percent were strongly agreed and 26.67% were not agreed in this point that pruning materials harm crop (Figure 27).

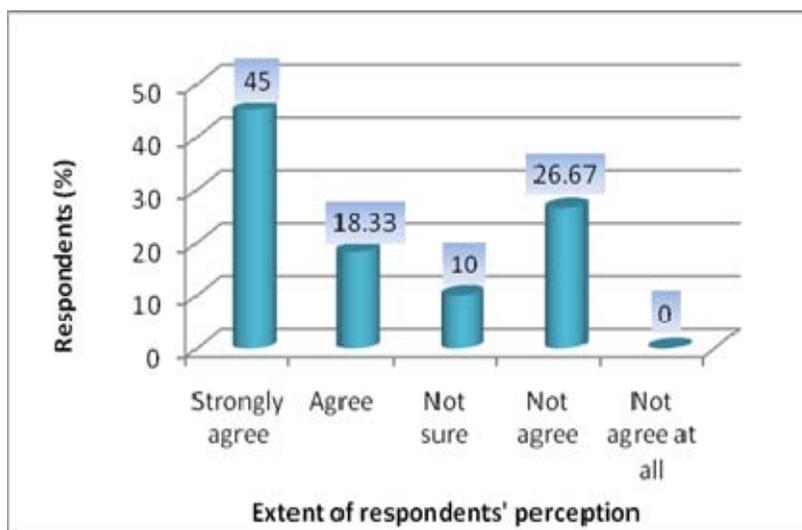


Figure 27 Farmers' perception regarding pruning material harms crop

11.1.1.11. Improvement of livelihood and food security through agroforestry practices

Given the multiple benefits of agroforestry discussed, there is no doubt that agroforestry products are a great improvement to livelihoods. The respondent was provided with a 5 point likert scale to rate agroforestry's contributions towards improvement of their livelihoods.

It includes following points to be opined by the farmers

- Health & nutritional improvement
- Life style improvement
- Interrelation between producer & consumer
- Value addition
- Marketing development
- Germplasm introduction
- Adaptability on dry land

11.1.1.11.1. Health & nutritional improvement: Farmers opined that agroforestry practices play a great role in their family demand for nutritional requirement. Many homestead fruit trees were provide nutrition as well as timber. Tree species also provide shade and make the environment cool. Thus, they are living in a healthy environment by satisfying their nutritional need. With this view most of the respondents (96.67%) strongly agreed that agroforestry practices help in improvement of health and nutrition (Figure 28).

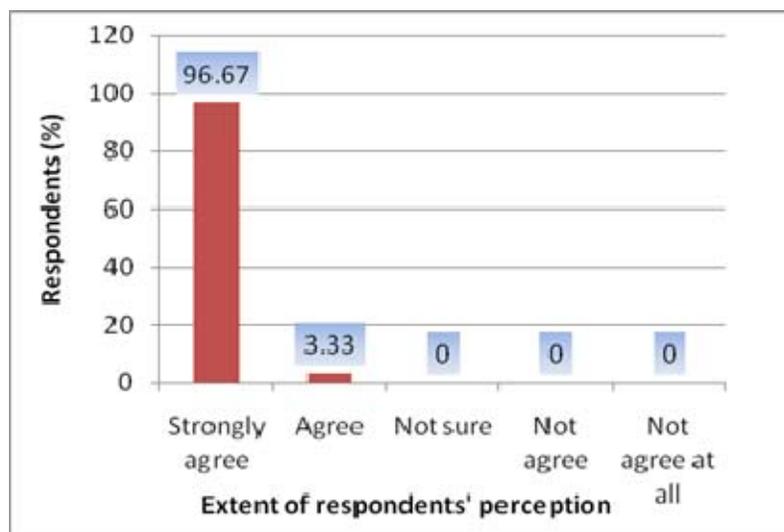


Figure 28 Farmers' perception regarding health & nutritional improvement

11.1.1.11.2. Life style improvement: Most of the farmers were strongly agreed and rests were agreed in this regard that agroforestry practices are improving their life style. They are financially capable to lead their life properly. They are now capable of feeding their family and schooling their children (Figure 29).

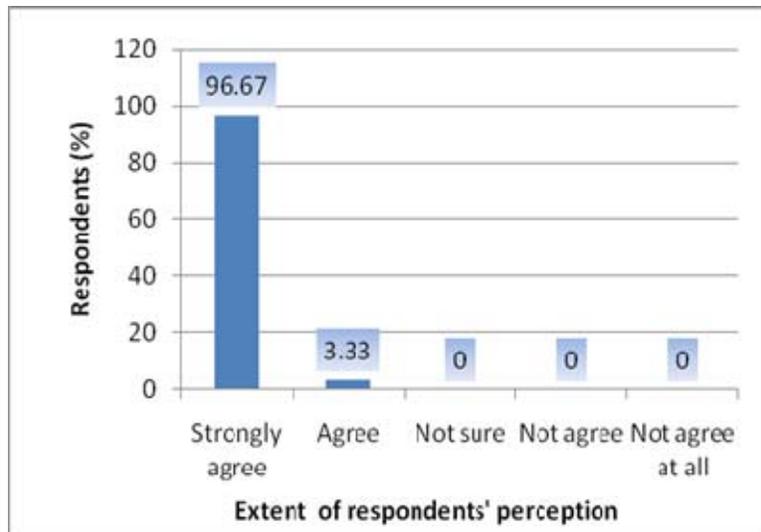


Figure 29 Farmers' perception regarding life style improvement

11.1.1.11.3. Interrelation between producer & consumer: According to farmers, agroforestry practices developed a good interrelation between producers and consumers. Almost all the farmers opined this (86.67%) (Figure 29).

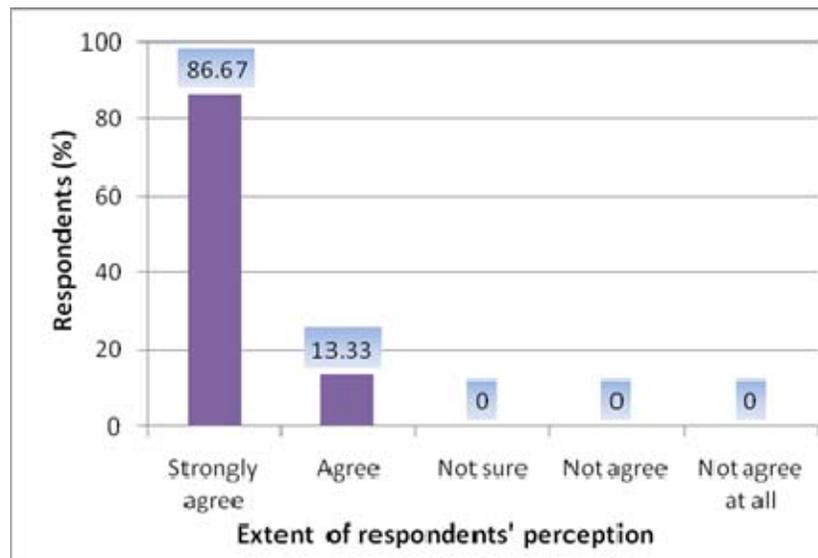


Figure 30 Farmers' perception regarding interrelation between producer & consumer

11.1.1.11.4. Value addition: In the study area, farmers only grow raw products. They do not process it further for value addition. Value addition is a new term for them and they take it quite risky. Also in their area, there is no sufficient processing industry which can add product value. Thus 100% of the farmers were not agreed with the point that agroforestry practice help in value addition (Figure 31).

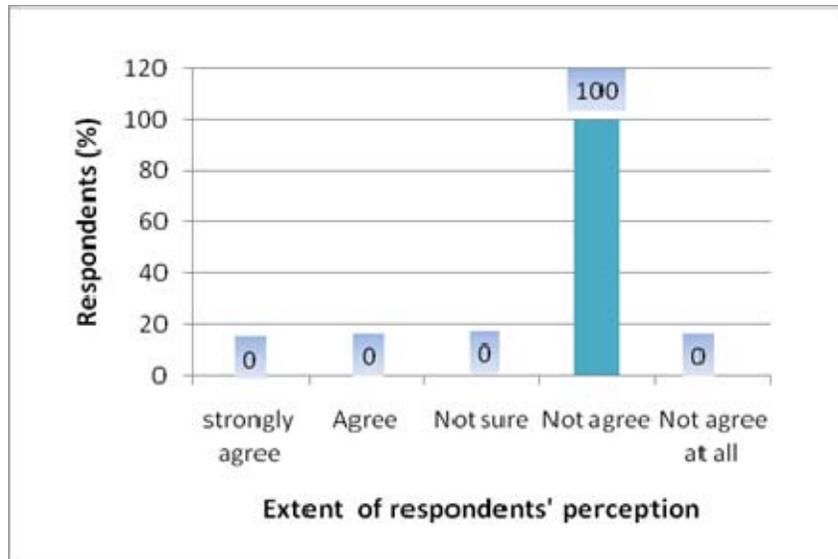


Figure 31 Farmers' perception regarding value addition

11.1.1.11.5. Marketing development: About 83.33% respondents were strongly agree that agroforestry brought positive change for marketing development. Proper marketing system is not so much available there. But farmers seemed that if there was proper system, it would be more beneficial for them and they could get maximum profit from production (Figure 32).

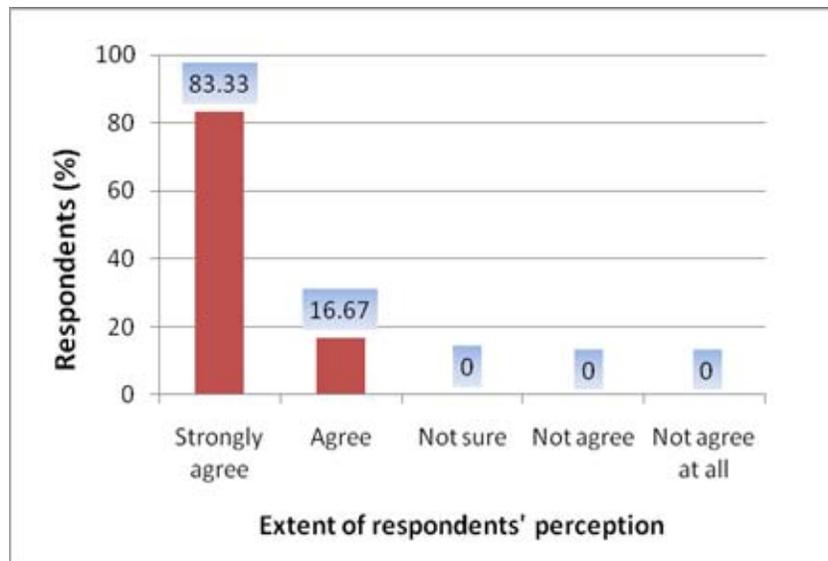


Figure 32 Farmers' perception regarding marketing development

11.1.1.11.6. Germplasm introduction: Germplasm introduction is a quite unfamiliar term for them. Thus 100% of them were not sure about it (Figure 33).

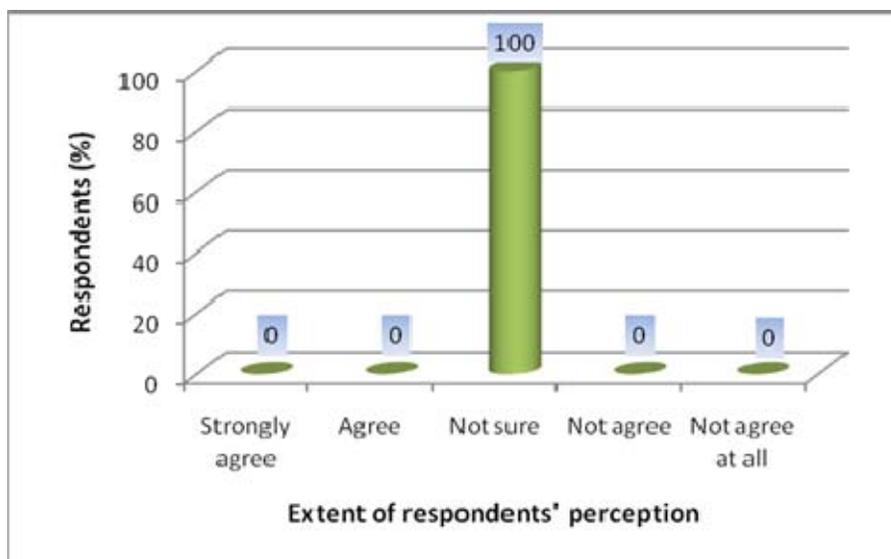


Figure 33 Farmers' perception regarding germplasm introduction

11.1.1.11.7. Adaptability on dry land: About 47% were strongly agreed and 53.33 were agreed in this point that agroforestry facilitated their crop adaptability on dry land (Figure 34).

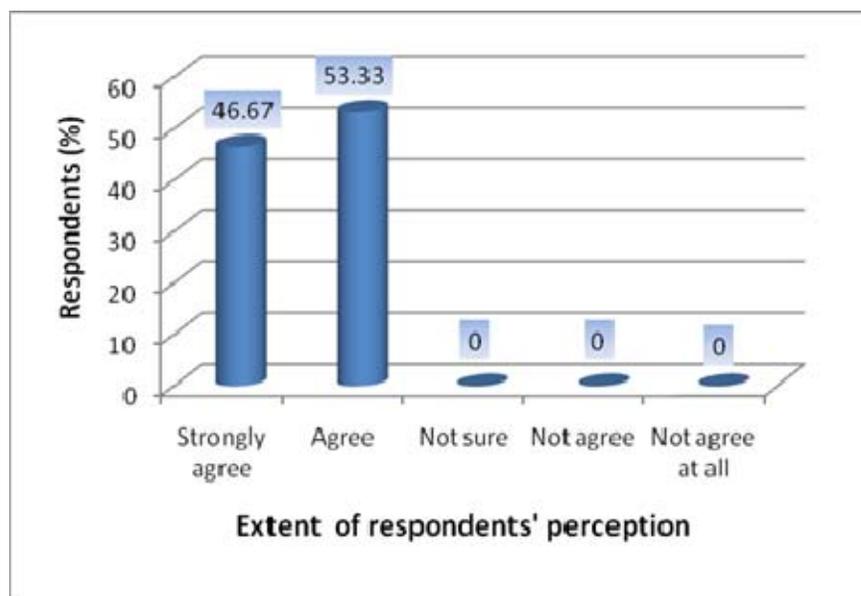


Figure 34 Farmers' perception regarding adaptability on dry Land

11.1.2. Jaintiapur upazila

11.1.2.1. Selected socio-economic characteristics of the farmers

Data were collected for fourteen socio-economic characteristics of the respondents. A summary of the analyzed result for the selected socio-economic characteristics of the farmers is shown in table 24.

Table 24. Salient features of the selected Socio-economic characteristics of the farmers

Characteristics	Unit of measurement	Observed range	Mean	Standard deviation
Age	Year	28-87	47.90	14.64
Education level	Year of schooling	0-12	3.92	3.52
Family size	Number	2-22	7.75	3.85
Farm size	Hectare	0.04-7.16	1.45	1.30
Annual family income	Thousand Tk.	94.91-360.00	139.39	94.91
Credit received	Dummy			
Remittance received	Dummy			
Agricultural training	Dummy			
Extension contact	No. of visit per year	0-24	7.33	7.10
Involvement in a society/ organization	Dummy			
Land topography	Dummy			
Erosion hazard	Dummy			
Distance to local market	Km	0.50-6.00	1.66	0.92
Distance to road	Km	0.01-3.00	0.82	0.72

Each of the fourteen characteristics is described below along with mean, standard deviation and range. Farmers were classified into several categories according to relevant data obtained against each of the characteristics and presented in respective table.

11.1.2.1.1. Age

On the basis of National Youth policy, respondents were classified into three categories namely Young (18 - 35 years), Middle aged (36 - 50 years) and Old (above 50 years). The observed age of the respondents ranged from 28 to 87 years with the mean being 47.90 and

the standard deviation was 14.64. Distribution of the farmers according to their age is shown in table 25.

Table 25 Distribution of the farmers according to age

Categories (Years)	Number	Percent	Mean	Standard deviation
Young aged (18-35)	36	35.3		
Middle aged (36-50)	14	13.7	47.90	14.64
Old aged (above 50)	52	51.0		
Total	102	100		

11.1.2.1.2. Education level

Education level of the respondents were classified into four categories namely Illiterate (0), Primary (1-5), Secondary (6-10) and Higher studies and above (11 & above) considering their year of schooling. The education level of the respondents ranged from 0 to 12 with the mean of 3.92 and the standard deviation was 3.52. Distribution of the farmers according to their education level is shown in the table 26.

Table 26 Distribution of the farmers according to education level

Education level (Schooling years)	Number	Percent	Mean	Standard deviation
Illiterate (0)	37	36.3		
Primary (1-5)	52	51.0		
Secondary (6-10)	6	5.9	3.92	3.52
Higher studies (11&above)	7	6.9		
Total	102	100		

11.1.2.1.3. Family size

The respondents were classified into three categories namely Small family (<5), Medium family (5-8) and Large family (>8). Family size of the respondents varied from 2 to 22 with the mean of 7.75 and standard deviation was 3.85. Distribution of the farmers according to their family size is shown in the table 27.

Table 27 Distribution of the farmers according to family size

Categories(Number)	Number	Percent	Mean	Standard deviation
Small family (<5)	14	13.7		
Medium family (5-8)	62	60.8	7.75	3.85
Large family (>8)	26	25.5		
Total	102	100		

11.1.2.1.4. Farm size

On the basis of the respondent's total farm size they were classified into four categories namely landless & marginal (<0.21 hectare), small (0.21-1.0 hectare), medium (1.1-3.0 hectare) and large (>3.0 hectare). The farm size of the respondents ranged from 0.04 to 7.16 hectares with the mean of 1.45 and the standard deviation was 1.30. Distribution of the farmers according to their farm size is shown in table 28.

Table 28 Distribution of the farmers according to farm size

Categories (hectare)	Number	Percent	Mean	Standard deviation
Landless & marginal(<0.21)	2	1.96		
Small (0.21-1.0)	43	42.16	1.45	1.30
Medium (1.1-3.0)	48	47.06		
Large(>3.0)	9	8.82		
Total	102	100		

11.1.2.1.5. Annual family income

Family income of the respondents ranged from BDT 94,910 to 3,60,000 with a mean of 139.39 and standard deviation of 94.91. Based on their family income, the respondents were classified into three categories: low income (up to Tk. 100,000), medium income (Tk. 101,000 to 200,000) and high income (above Tk. 201,000). Distribution of the farmers according to their annual family income is shown in table 29.

Table 29 Distribution of the farmers according to annual family income

Categories (Thousand "000" TK.)	Number	percent	Mean	Standard deviation
Low income (Up to 100)	50	49.0		
Medium income (101-200)	30	29.4	139.39	94.91
High income (above 201)	22	21.6		
Total	102	100		

11.1.2.1.6. Credit received

Respondents were classified into two categories as credit received & not received. Distribution of the farmers according to credit received is shown in table 30.

Table 30 Distribution of the farmers according to agricultural credit received

Categories (Dummy)	Number	Percent
Received(1)	29	28.4
Not Received(0)	73	71.6
Total	102	100

11.1.2.1.7. Remittance received

Respondents were classified into two categories as remittance received & not received. Distribution of the farmers according to remittance received is shown in table 31.

Table 31 Distribution of the farmers according to remittance received

Categories (Dummy)	Number	Percent
Received(1)	10	9.8
Not Received(0)	92	90.2
Total	102	100

11.1.2.1.8. Agricultural training

Respondents were classified into two categories as training received & not received. Distribution of the farmers according to training received is shown in table 32.

Table 32 Distribution of the farmers according to agricultural training experience

Categories (Dummy)	Number	Percent
Received(1)	40	39.2
Not Received(0)	62	60.8
Total	102	100

11.1.2.1.9. Extension contact

Respondents were classified into three categories as low extension contact (up to 9), medium extension contact (10-16) and high extension contact (>16). Agricultural extension contact score of the respondents ranged from 0 to 24 while mean being 7.33 and standard deviation was 7.10 respectively. Distribution of the farmers according to their agricultural extension contact is shown in table 33.

Table 33 Distribution of the farmers according to extension contact

Categories (No. of visit per year)	Number	Percent	Mean	Standard deviation
Low extension contact (Up to 9)	59	57.8		
Medium extension contact(10-16)	34	33.3	7.33	7.10
High extension contact (>16)	9	8.8		
Total	102	100		

11.1.2.1.10. Involvement in a society/organization

Respondents were classified into two categories as involved & not involved in a society/organization. Distribution of the farmers according to their involvement in a society/organization is shown in table 34.

Table 34 Distribution of the farmers according to involvement in a society or organization

Categories (Dummy)	Number	Percent
Involved(1)	34	33.3
Not Involved (0)	68	66.7
Total	102	100

11.1.2.1.11. Land topography

In the study area both plain and slope land topography was found. Distribution of the farmers according to land topography is shown in table 35.

Table 35 Distribution of the farmers according to land topography

Categories (Dummy)	Number	Percent
Plain(1)	59	57.8
Slope(2)	34	33.3
Both(3)	9	8.8
Total	102	100

11.1.2.1.12. Erosion hazard

Respondents were classified into two categories as erosion hazard found & not found in their field. Distribution of the farmers according to erosion hazard found is shown in table 36.

Table 36 Distribution of the farmers according to agricultural erosion hazards

Categories (Dummy)	Number	Percent
Found(1)	38	37.3
Not found(0)	64	62.7
Total	102	100

11.1.2.1.13. Distance from home to local market

Distance from home to local market of the respondents was classified into three categories as little, moderate, and high. Distance from home to local market of the respondents ranged from 0.05 to 6.0 with a mean of 1.66 and standard deviation of 0.92. Distribution of the farmers according to distance from home to local market is shown in table 37.

Table 37 Distribution of the farmers according to distance from home to local market

Categories(Km)	Number	percent	Mean	Standard deviation
Little(<1)	88	86.3		
Moderate(1-2)	12	11.7	1.66	0.92
High(>2)	2	2.0		
Total	102	100		

11.1.2.1.14. Distance from home to road

Distance from home to road of the respondents was classified into three categories as little, moderate, and high. Distance from home to road of the respondents ranged from 0.01 to 3.00 with a mean of 0.82 and standard deviation of 0.72. Distribution of the farmers according to distance from home to road is shown in table 38.

Table 38 Distribution of the farmers according to distance from home to road

Categories(Km)	Number	percent	Mean	Standard deviation
Little(<1)	65	62.7		
Moderate(1-2)	32	31.4	0.82	0.72
High(>2)	6	5.9		
Total	102	100		

11.1.2.2. Farmers’ involvement in production activities

Farmers were involved in different production activities viz. homestead agroforestry, livestock, field crop production, roadside agroforestry, citrus based agroforestry, aquaforestry, pineapple based agroforestry, cropland agroforestry, betel leaf agroforestry , black pepper based agroforestry, drumstick production, apiculture, agar plantation and others production practices. Among the production activities most of the respondents were involved in homestead agroforestry (96%), Livestock rearing (96%) and field crop production. Distribution of the farmers depending on their involvement in production activities is shown in figure 35.

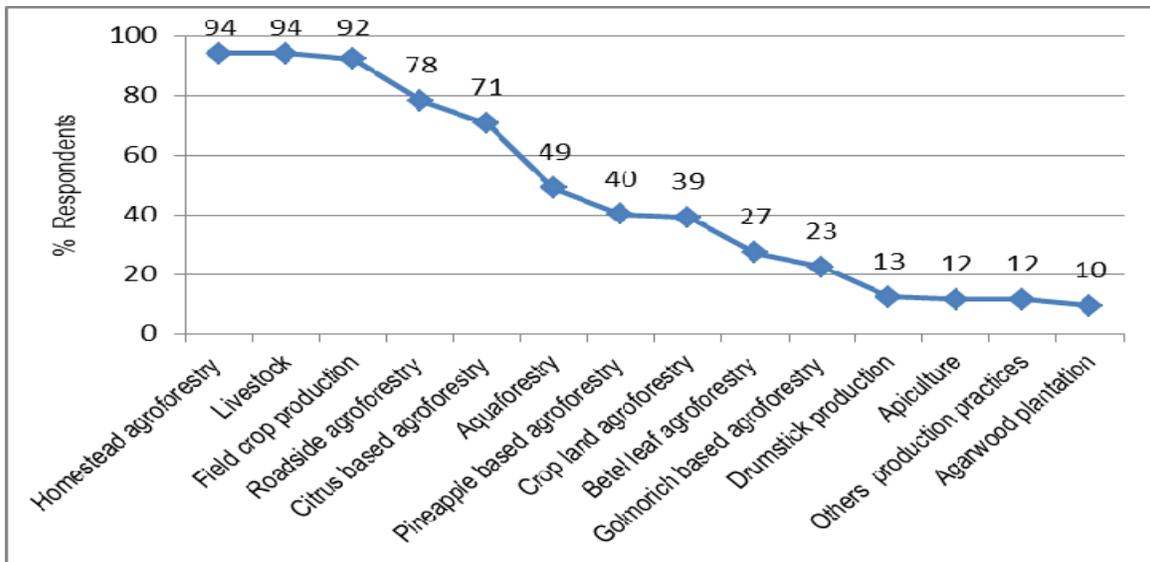


Figure 35 Distribution of the farmers depending on their involvement in production activities

11.1.2.3. Source of propagation materials

In the study area it was reported that farmers collect propagation materials from different sources viz. seed bank, seed producers, own production, neighbors, dealer, local market, and others. Distribution of the farmers according to their sources of propagation material is shown in figure 36.

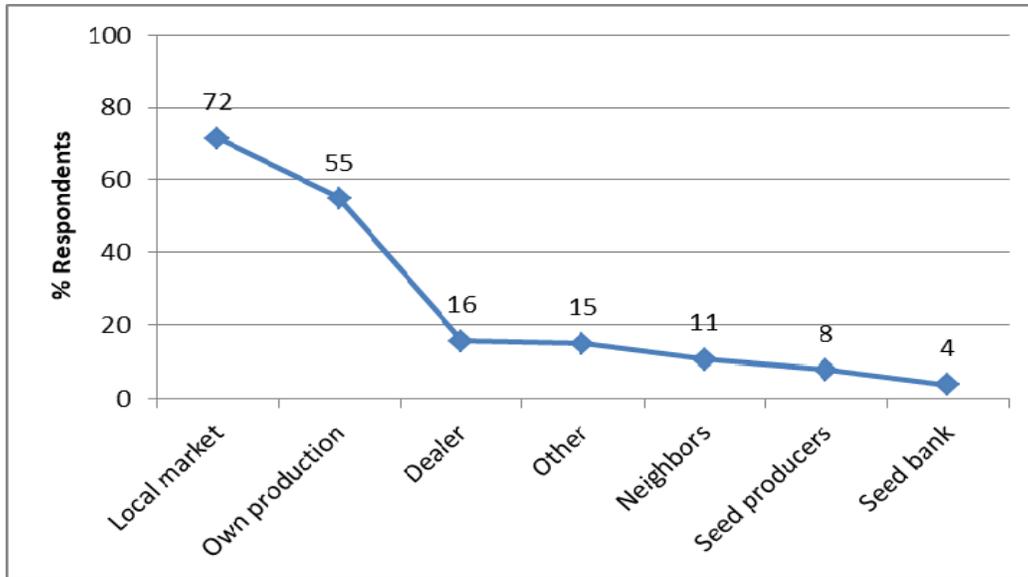


Figure 36 Distribution of the farmers according to their source of propagation material

11.1.2.4. Traditional management practices

In the study area farmers apply different traditional management practices in tree and crop production viz. fertilization, mulching, irrigation, drainage, staking, training, pruning, weeding and pesticide application. Distribution of the farmers according to the management practices they apply in crop production and tree production are shown in figure 37 (a) and (b).

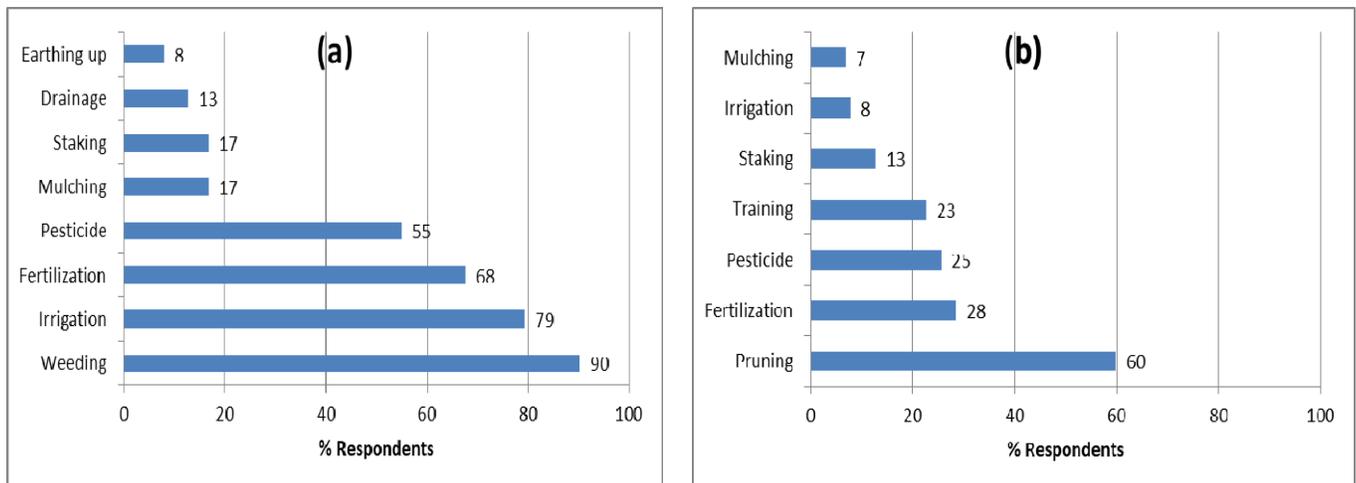


Figure 37 Distribution of the farmers according to the management practices they apply in crop production (a) and tree production (b)

11.1.2.5. Plant species diversity

Diversified plant species were observed in the study area. Total 98 plant species were recorded from the survey area of which 28 were fruit species, 27 were vegetable species, 13 were timber species, 11 were medicinal species, 9 were spice species, 5 were crop species and 4 were non timber species. Among fruit, vegetable, timber, medicinal, spice, crop and non-timber species jackfruit (86.27%), lemon (80.39%), country bean (39.22%), bottle gourd (33.33%), mangium (45.10%), mehogony (41.18%), neem (47.06%), arjun (39.22%), chilli (27.45%), nagamorich (25.49%), rice (86.27%) and bamboo (41.18%) were grown by most of the respondents in the study area. Distribution of the farmers according to fruit, vegetable, timber, medicinal, spice, crop and non timber species they cultivate are shown in table 39 to table 45, respectively.

Table 39 Distribution of the farmers according to fruit species they cultivate

Common name	Scientific name	Frequency	Percentage
Jackfruit (Kanthal)	<i>Artocarpus heterophylus</i>	88	86.27
Lemon (Lebu)	<i>Citrus limon</i>	82	80.39
Mango (Aam)	<i>Mangifera indica</i>	80	78.43
Papaya (Pepe)	<i>Carica papaya</i>	64	62.75
Blackberry (Jaam)	<i>Syzygium cumini</i>	48	47.06
Guava (Peyara)	<i>Psidium guava</i>	40	39.22
Coconut (Narikel)	<i>Cocos Nucifera</i>	32	31.37

Common name	Scientific name	Frequency	Percentage
Litchi (Lichu)	<i>Litchi chinensis</i>	32	31.37
Jujubi(Boroi)	<i>Zizpus mauritania</i>	29	28.43
Pummelo (Jambura)	<i>Citrus grandis</i>	28	27.45
Pineapple (Anarosh)	<i>Ananas comosus</i>	26	25.49
Banana (kola)	<i>Musa paradiscum</i>	22	21.57
Orange (Komola)	<i>Citrus aurentium</i>	20	19.61
Golden apple (Amra)	<i>Spondias pinnata</i>	16	15.69
Burmese grape (Lotkon)	<i>Baccaurea ramiflora</i>	16	15.69
Sweet orange (Malta)	<i>Citrus sinensis</i>	12	11.76
Watermelon (Tormuj)	<i>Citruluas vulgaris</i>	10	9.8
Matur	Local sp.	10	9.8
Carambola (Kamranga)	<i>Averrhoa carambola</i>	8	7.84
Rata	Local sp.	8	7.84
Bullock's heart (Atafo)	<i>Annona reticulata</i>	6	5.88
Olive (Jolpai)	<i>Elaeocarpus floribundus</i>	6	5.88
Wood apple (Bel)	<i>Aegle marmelos</i>	4	3.92
Ol boroi	Local sp.	4	3.92
Monkey jack (Deowa)	<i>Artocarpus lakoocha</i>	4	3.92
Matur	Local sp.	3	2.94
Date palm (Khejur)	<i>Phoenix sylvestris</i>	2	1.96
Tamarind (Tentul)	<i>Tamarindus indica</i>	2	1.96

Table 40 Distribution of the farmers according to vegetable species they cultivate

Common name	Scientific name	Frequency	Percentage
Country bean (Shim)	<i>Lablab purpureus</i>	40	39.22
Bottle gourd (Lao)	<i>Lagenaria siceraria</i>	34	33.33
Red amaranth (Lalshak)	<i>Amaranthus cruentus</i>	34	33.33
Tomato	<i>Lycopersicon esculentum</i>	25	24.5
Indian spinach (Puishak)	<i>Basella alba</i>	25	24.5
Raise gourd (Jhinga)	<i>Luffa acutangula</i>	22	21.56
Brinjal (Begun)	<i>Solanum melongena</i>	20	19.61
Sweet gourd (Misti kumra)	<i>Cucurbita maxima</i>	16	15.69
Bitter gourd (Korola)	<i>Momordica charantia</i>	12	11.76
White gourd (Chal kumra)	<i>Benincasa hispida</i>	12	11.76
Amaranth (Datashak)	<i>Amaranthus lividus</i>	12	11.76
Yard long bean (Barbati)	<i>Vigna sesquipedalis</i>	10	9.8
Potato (Alu)	<i>Solanum tuberosum</i>	10	9.8
Snake gourd (Chichinga)	<i>Trichosanthes cucumerina</i>	8	7.84
Cucumber (Shosha)	<i>Cucumis sativas</i>	8	7.84

Common name	Scientific name	Frequency	Percentage
Spinach (Palongshak)	<i>Spinacia oleracea</i>	8	7.84
Water spinach (Kolmishak)	<i>Ipomoea aquatica</i>	8	7.84
Mustard green (Raishak)	<i>Brassica campestris</i>	8	7.84
Okra (Dheros)	<i>Abelmoschus esculentus</i>	6	5.88
Radish (Mula)	<i>Raphanus sativus</i>	6	5.88
Pointed gourd (Potol)	<i>Tricosanthes diocia</i>	6	5.88
Lettuce	<i>Lactuca sativa</i>	4	3.92
Drumstick (Sajna)	<i>Moringa oleifera</i>	4	3.92
Cabbage (Badhakopi)	<i>Brassica oleracia var. capitata</i>	4	3.92
Teasle gourd (Kakrol)	<i>Momordica diocia</i>	4	3.92
French bean	<i>Phaseolus vulgaris</i>	2	1.96
Kachu	<i>Colocasia esculenta</i>	2	1.96

Table 41 Distribution of the farmers according to timber species they cultivate

Common name	Scientific name	Frequency	Percentage
Mangium	<i>Acacia mangium</i>	46	45.10
Mehogany	<i>Swietenia macrophylla</i>	42	41.18
kadam	<i>Anthocephalus chinensis</i>	36	35.29
Rain tree	<i>Samanea saman</i>	34	33.33
Acacia (Akashmoni)	<i>Acacia auriculiformis</i>	24	23.53
Koroi	<i>Albizia spp.</i>	24	23.53
Gamar	<i>Gmelina arborea</i>	10	9.80
Teak (Shegun)	<i>Tectona grandis</i>	6	5.88
Lambul	Local sp.	4	3.92
Jarul	<i>Lagerstroemia speciosa</i>	2	1.96
Champakul	Local sp.	2	1.96
Ramai	Local sp.	2	1.96
Awal	Local sp.	2	1.96

Table 42 Distribution of the farmers according to medicinal species they cultivate

Common name	Scientific name	Frequency	Percentage
Neem	<i>Azadirachta indica</i>	48	47.06
Arjun	<i>Terminalia arjuna</i>	40	39.22
Tulsi	<i>Ocimum sanctum</i>	20	19.61
Haritaki	<i>Terminalia chebula</i>	14	13.73
Mehendi	<i>Lawsonia inermis</i>	6	5.88
Thankuni	<i>Centella asiatica</i>	4	3.92

Common name	Scientific name	Frequency	Percentage
Emblic (Amloki)	<i>Phyllanthus emblica</i>	4	3.92
Ruijat	Local sp.	4	3.92
Dhutura	<i>Datura metel</i>	2	1.96
Basak	<i>Adhatoda vasica</i>	2	1.96
Amburoj	Local sp.	2	1.96

Table 43 Distribution of the farmers according to spice species they cultivate

Common name	Scientific name	Frequency	Percentage
Chilli (Marich)	<i>Capsicum frutescens</i>	28	27.45
Nagamarich	<i>Capsicum chinense</i>	26	25.49
Turmeric (Halud)	<i>Curcuma longa</i>	12	11.76
Onion (peyaz)	<i>Allium cepa</i>	8	7.84
Pepper (Golmorich)	<i>Piper nigrum</i>	8	7.84
Ginger (Ada)	<i>Zingiber officinale</i>	8	7.84
Coriander (Dhaniya)	<i>Coriandrum sativum</i>	6	5.88
Garlic (Rashun)	<i>Allium sativum</i>	4	3.92
Bay leaf (Tejpata)	<i>Cinnamomum tamala</i>	3	2.94

Table 44 Distribution of the farmers according to crop species they cultivate

Common name	Scientific name	Frequency	Percentage
Rice	<i>Oryza sativa</i>	88	86.27
Wheat	<i>Triticum aestivum</i>	6	5.88
Maize	<i>Zea mays</i>	4	3.92
Lentil	<i>Lens culinaris</i>	3	2.94
Peanut	<i>Arachis hypogaea</i>	2	1.96

Table 45 Distribution of the farmers according to non-timber species they cultivate

Common name	Scientific name	Frequency	Percentage
Bamboo (Bash)	<i>Bamboosa aridinarifolia</i>	42	41.18
Betel nut (Supari)	<i>Areca catechu</i>	36	35.29
Murta	<i>Schumannianthus dichotomus</i>	24	23.53
Betel leaf (Pan)	<i>Piper betle</i>	10	9.80

11.1.2.7.1. Newly planted species

In the study area it is found that the cultivation of 31 plant species has increased. Distribution of the farmers according to newly planted species is shown in table 46.

Table 46 Distribution of the farmers according to newly planted species

Common name	Scientific name	Frequency	Percentage
Mangium	<i>Acacia mangium</i>	22	21.57
Rain tree	<i>Samanea saman</i>	14	13.73
Rice	<i>Oryza sativa</i>	12	11.76
Jackfruit	<i>Artocarpus heterophylys</i>	12	11.76
Acacia	<i>Acacia auriculiformis</i>	10	9.80
Kadam	<i>Anthocephalus chinensis</i>	8	7.84
Bamboo	<i>Bamboosa aridinarifolia</i>	6	5.88
Mehogany	<i>Swietenia macrophylla</i>	4	3.92
Gamar	<i>Gmelina arborea</i>	4	3.92
Pummelo	<i>Citrus grandis</i>	4	3.92
Ginger	<i>Zingiber officinale</i>	4	3.92
Garlic	<i>Allium sativum</i>	4	3.92
Pineapple	<i>Ananas comosus</i>	4	3.92
Maize	<i>Zea mays</i>	4	3.92
Lemon	<i>Citrus limon</i>	4	3.92
Chakarchi	Local sp.	4	3.92
Mango	<i>Mangifera indica</i>	2	1.96
Emblic	<i>Phyllanthus emblica</i>	2	1.96
Country bean	<i>Lablab purpureus</i>	2	1.96
Lettuce	<i>Lactuca sativa</i>	2	1.96
Betel nut	<i>Areca catechu</i>	2	1.96
Palm oil	<i>Elaeis guineensis</i>	2	1.96
Nagamarich	<i>Capsicum chinense</i>	2	1.96
Mustard	<i>Brassica campestris</i>	2	1.96
Yard long bean	<i>Vigna sesquipedalis</i>	2	1.96
Sweet orange	<i>Citrus sinensis</i>	2	1.96
Litchi	<i>Litchi chinensis</i>	2	1.96
Wheat	<i>Triticum aestivum</i>	2	1.96
Koroi	<i>Albizia spp.</i>	2	1.96
Amburoj	Local sp.	2	1.96
Ol boroi	Local sp.	2	1.96

11.1.2.7.2 Species that decreased

It is found in the study area that the cultivation of 23 plant species has decreased. Distribution of the farmers according to decreased plant species is shown in table 47

Table 47 Distribution of the farmers according to decreased plant species

Common name	Scientific name	Frequency	Percentage
Jarul	<i>Lagerstroemia speciosa</i>	6	5.88
Bay leaf	<i>Cinnamomum tamala</i>	6	5.88
Neem	<i>Azadirachta indica</i>	6	5.88
Tulshi	<i>Ocimum sanctum</i>	5	4.90
Bot	<i>Ficus bengalensis</i>	4	3.92
Teak	<i>Tectona grandis</i>	4	3.92
Blackberry	<i>Syzygium cumini</i>	4	3.92
Rata	Local sp.	4	3.92
Watermelon	<i>Citrulus vulgaris</i>	4	3.92
Arjun	<i>Terminalia arjuna</i>	2	1.96
Sissoo	<i>Dalbergia sissoo</i>	2	1.96
Tulshi	<i>Ocimum sanctum</i>	2	1.96
Bullock's heart	<i>Annona reticulata</i>	2	1.96
Pumello	<i>Citrus grandis</i>	2	1.96
Sugercane	<i>Saccharum officinarum</i>	2	1.96
Agar	<i>Aquilaria malaccensis</i>	2	1.96

11.2. Study 2: Status of Climate-Smart Agriculture practices

11.2.1. Golapgonj upazila

11.2.1.1. Farmers' Perception Regarding Climate Change & It's Impact on Agriculture

Distribution of the farmers according to their perception on experiencing climate change is shown in table 4.13

11.2.1.1.1. Perceptions on experiencing climate change

The respondents were asked about their perceived experience in relation to a series of climatic events commonly associated with global climate change effects in Bangladesh. They could

respond selecting the following; experienced increases, decreases, no change, or they did not know, in the occurrence of the event.

Table 47 reports the farmers’ response to individual climatic events. Here, all respondents indicated that they had experienced increases in lightening, rainfall, unpredictable rain, earthquake, fog, cloudy sky. Across all events, lightening has increased according to 85% of the respondents. 73.3% respondents reported about the increasing trend of rainfall. The majority of farmers perceived an increasing trend of rainfall and lightening, increasing earthquake, cloudy sky and unpredictable rain may affect crop production. According to collected data, 90% respondents reported about decreasing trend of flash flood. Decreasing flash flood may help the farmers to achieve their production goal.

Table 47 Distribution of farmers to perceived changes in specific climatic events in Golapganj upazila (n=60)

Climatic Events	Respondents (%)							
	Increased		Decreased		No change		Don't know	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Lightening	51	85.0	0	0.0	0	0.0	9	15.0
Rainfall	44	73.3	4	6.7	0	0.0	12	20.0
Temperature	14	23.3	14	23.3	2	3.3	30	50.0
Drought	14	23.3	14	23.3	2	3.3	30	50.0
Flash flood	0	0.0	54	90.0	2	3.3	4	6.7
Hailstorm	24	40.0	1	1.7	29	48.3	6	10.0
Unpredictable Rain	22	36.7	1	1.7	0	0.0	7	11.7
Earthquake	17	28.3	0	0.0	0	0.0	13	21.7
Fog	0	0.0	13	21.7	0	0.0	17	28.3
Cloudy Sky	12	20.0	0	0.0	0	0.0	18	30.0
Speedy wind	11	18.3	0	0.0	0	0.0	19	31.7

11.2.1.1.2. Perceptions regarding impact of climate change on farming systems

It was found that among all of the impacts, 98.3% respondents agreed on increasing about the impact on cost of crop production, 96.7% respondents agreed on increasing about the impact on pest attack. 98.3% respondents said that soil fertility has decreased. 38.3% respondents reported that crop failure had decreased (Table 48). As crop production cost, pest attack has

increased, necessary steps should also be taken so that the farmers will adopt this technique as it is environmental friendly and beneficial to improve soil fertility, soil structure with low cost of production.

Table 48 Responses of farmers on impact of climate change on farming systems in Golapganj upazila (n=60)

Types of impact	Respondents (%)							
	Increased		Decreased		No change		Don't know	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Crop failure	11	18.3	23	38.3	0	0	26	43.3
Cost of crop production	59	98.3	0	0.0	0	0	1	1.7
Pest attack	58	96.7	0	0.0	0	0	2	3.3
Soil fertility	0	0.0	59	98.3	0	0	1	1.7
Others	0	0.0	0	0.0	0	0	0	0.0

11.2.1.2. Existing climate-smart agricultural practices

In the study area, the farmers were asked about eighteen CSA practices whether these were practiced or not. Among them, they had practiced seventeen CSA practices viz. high yielding crop varieties, improved livestock varieties, adjusting planting time, farm yard manure, crop rotation, mulching, vermicomposting, farm yard manuring, rice-cum-fish farming, integrated pest management (IPM), pheromone trap, light trap, perching in paddy field, intercropping, agroforestry, short duration varieties, sorjan method, use of local pesticides. Distribution of the farmers according to CSA practices they follow is shown in figure

11.2.1.2.1. Extent of use of high yielding variety

It was found that 78.3% of the respondents highly used the high yielding varieties (HYV) while 10% of them used it in medium level and 11.6% used it in low level. (Figure 38) As major portion of the respondents grow high yielding varieties, so more suitable high yielding and modern varieties should be introduced in the locality to increase farmers ability to face climate change hazards.

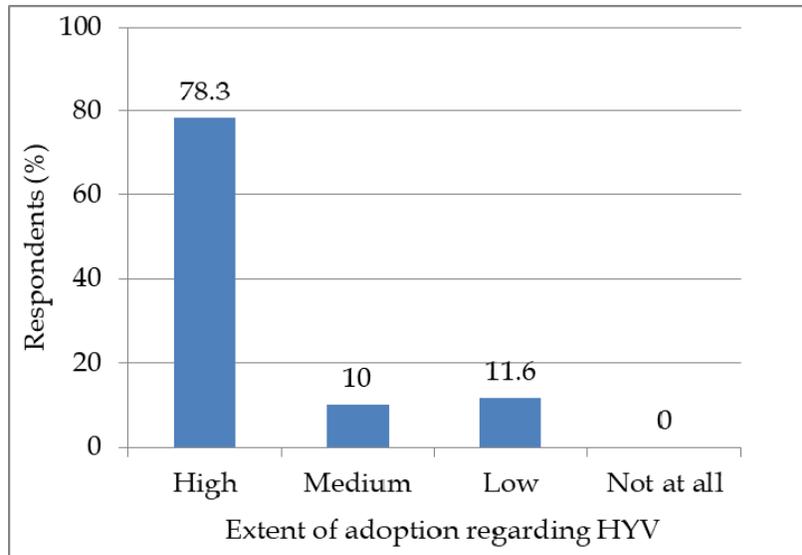


Figure 38 Extent of adoption regarding High Yielding Variety in Golapganj upazila

11.2.1.2.2. Improved livestock breed

It was found that 25% of the respondents highly used the improved livestock breed while 16.6% of them used it in medium level the improved livestock breed and 30% used in low level. 28.3% of the respondents did not use improved livestock breed at all (Figure 39). As a large portion of the respondents are out of touch of improved livestock breed, more suitable improved livestock breed should be introduced in the locality to increase farmers ability to increase their income.

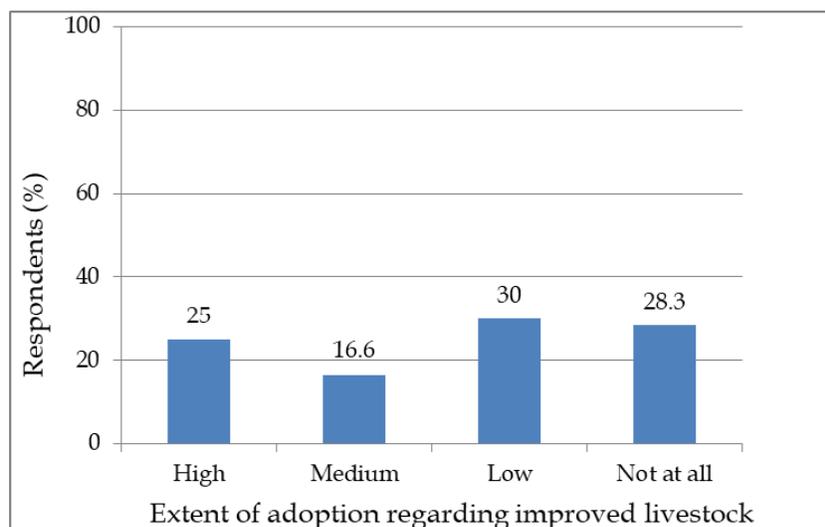


Figure 39 Extent of adoption regarding improved livestock in Golapganj upazila

11.2.1.2.3 Adjusting planting time

It was found that 51.6% of the respondents highly adjusted the planting time of crop varieties while 18.3% of them adjusted it in medium level, 25% of them adjusted the planting time in low level and only 5% did not adjust at all (Figure 40). As a large portion of the respondents do not adjust the time highly, effort should be given for adjusting the timing in the locality to increase farmers ability to face climate change hazards.

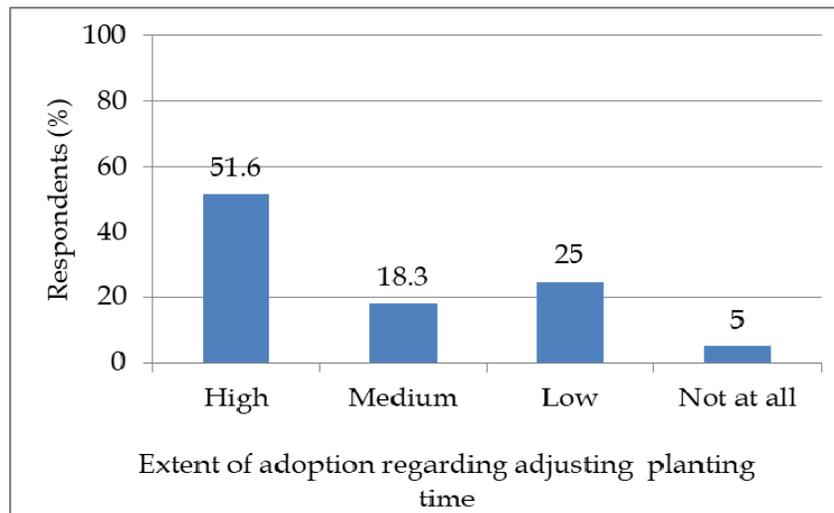


Figure 40 Extent of adoption regarding adjusting planting time in Golapganj upazila

11.2.1.2.4. Crop rotation

It was found that 38.3% of the respondents highly adopted crop rotation while 23.3% of them did not adopt crop rotation at all. 15% used crop rotation in medium level and 23.3% used it in low level (Figure 41). As a large portion of the respondents do not adopt the practice, effort should be given for adopting crop rotation in the study area to increase the productivity and to increase the soil fertility.

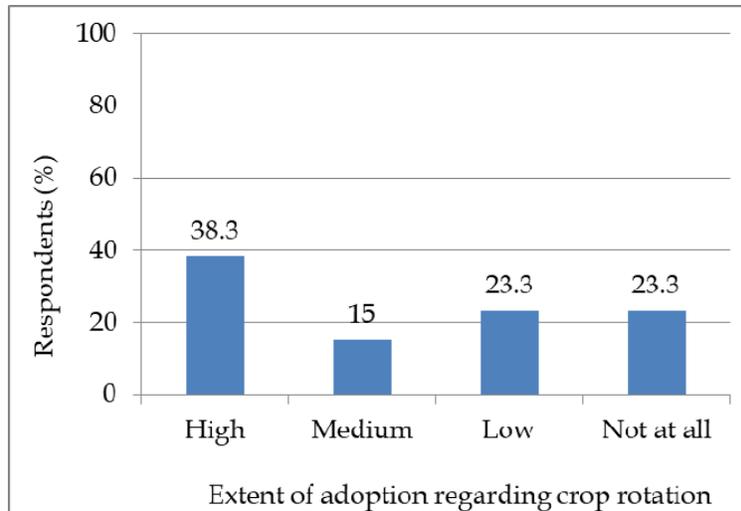


Figure 41 Extent of adoption regarding crop rotation in Golapganj upazila

11.2.1.2.5. Mulching

It was found that 46.6% of the respondents highly adopted mulching practice while 20% of them did not adopt mulching at all (Figure 42). As a large portion of the respondents do not adopt the practice, effort should be given for adopting mulching practice in the study area. Mulching helps to conserve moisture, helps to keep the soil cooler, improve the fertility and health of the soil and reduce weed growth. The layer of mulch also protects the soil from soil erosion, caused by wind and heavy rains.

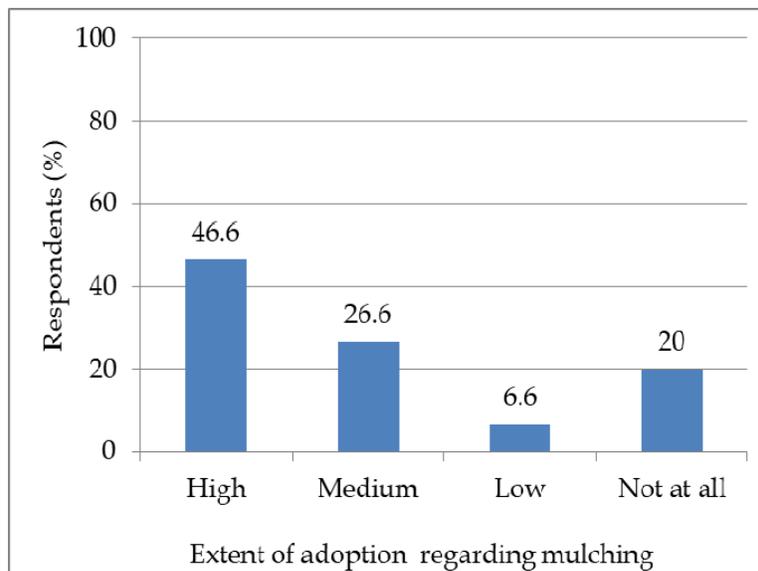


Figure 42 Extent of adoption regarding mulching in Golapganj upazila

11.2.1.2.6 Vermicomposting

It was reported that only 23.3% of the respondents highly adopted vermicomposting, 8.3% used it in medium level and 6.6% used it in low level while 61.6% of them did not adopt vermicomposting at all (Figure 43). As maximum portion of the respondents do not adopt the practice, effort should be given for adopting vermicomposting in the study area. This practice has relative advantages as a climate smart agricultural technique for increasing microbial activity as well as for increasing crop productivity. Vermicompost contains water-soluble nutrients and is an excellent, nutrient-rich organic fertilizer and soil conditioner. It is used in farming and small scale sustainable, organic farming.

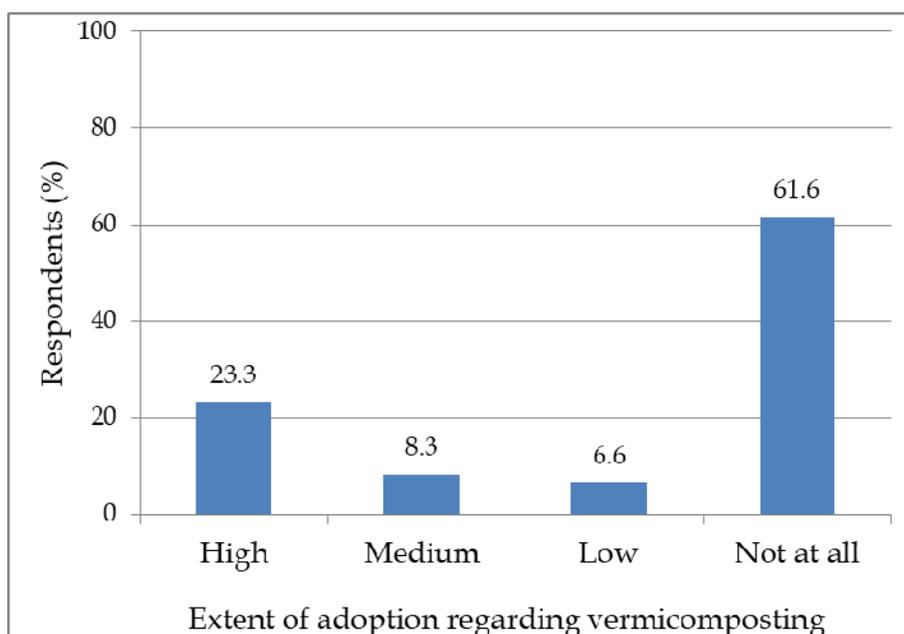


Figure 43 Extent of adoption regarding vermicomposting in Golapganj upazila

11.2.1.2.7 Farm yard manure:

It was reported that overall 68.2 % of the respondents used farm yard manure in which 46.6% of the respondents used FYM in high level, 10% in medium level and 11.6% in low level. 31.6% of them did not adopt vermicomposting at all (Figure 44). As a large portion of the respondents

do not adopt the practice, effort should be given for adopting farm yard manure in the study area to increase soil fertility as well as to increase crop productivity. It has relative advantages such as- it adds humus and slow releasing nutrients to the soil. Thus, this practice works as a climate smart agricultural technique

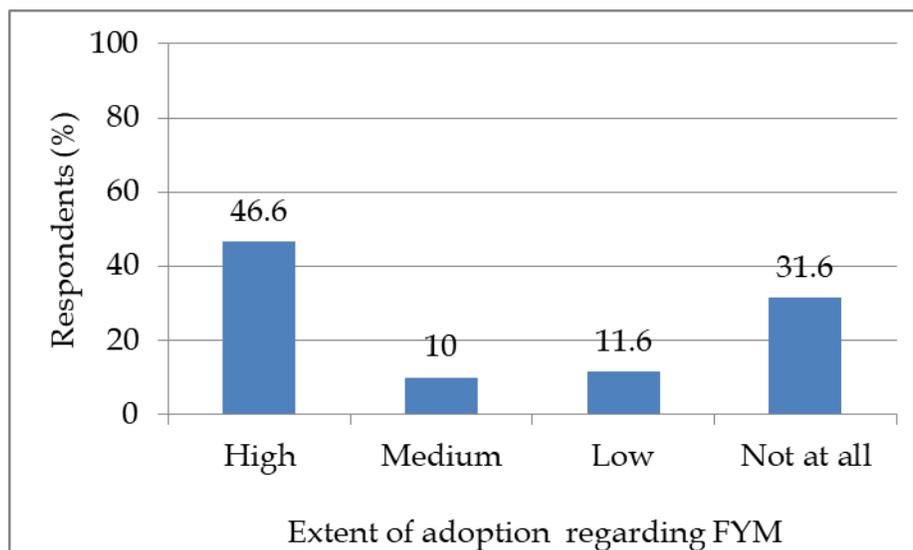


Figure 44 Extent of adoption regarding FYM in Golapganj upazila

11.2.1.2.8. Rice-cum-fish farming

Results revealed that only 10% of the respondents adopted rice cum fish farming in high level while 5% did it in medium level, 8.3% did it in low level and 76.6% of them did not adopt it at all (Figure 45). As maximum farmers did not use rice cum fish farming in their field, necessary steps should be taken to introduce them with the profit and relative advantages of this practice as a climate smart agricultural technique.

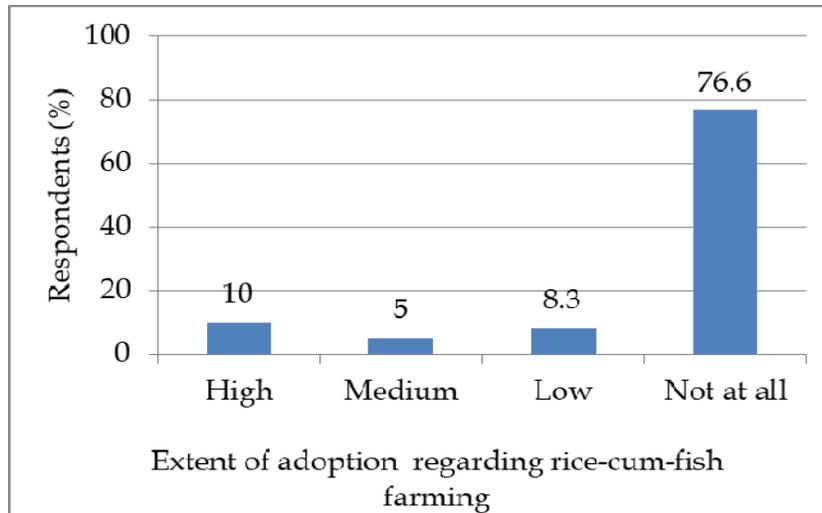


Figure 45 Extent of adoption regarding rice-cum-fish farming in Golapganj upazila

11.2.1.2.9. Integrated pest management

Results revealed that 43.3% of the respondents adopted Integrated pest management (IPM) highly while 13.3% adopted it in medium level, 8.3% adopted in low level and 35% of them did not adopt it at all (Figure 46). As a large portion of the farmers did not use IPM technique in their field, training on IPM should be provided to the farmers to introduce them with the profit and relative advantages of this practice as a climate smart agricultural technique. This technique is very environmental friendly because IPM reduces the need for pesticides by using several pest management methods.

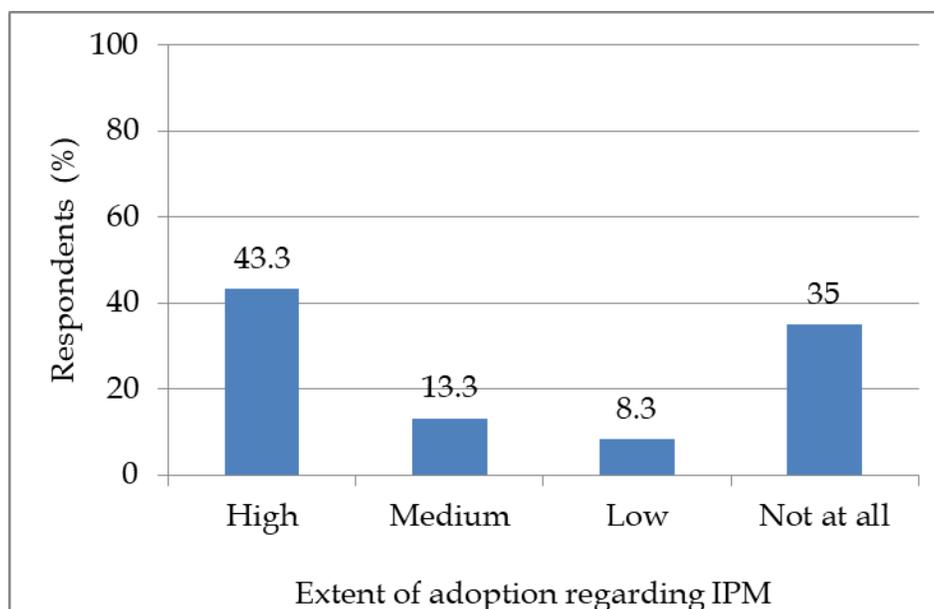


Figure 46 Extent of adoption regarding IPM in Golapganj upazila

11.2.1.2.10. Pheromone trap

Results revealed that 35% of the respondents adopted pheromone trap highly while 15% used it in medium level, 5% used it in low level and 45% of them did not adopted it at all (Figure 47). As a large portion of the farmers did not use pheromone technique in their field, hands on training program could be provided to the farmer to introduce them with the profit and relative advantages of this practice as a climate smart agricultural technique. This technique is very important because it is a great pest control tool that is used to help monitor & control insect infestations.

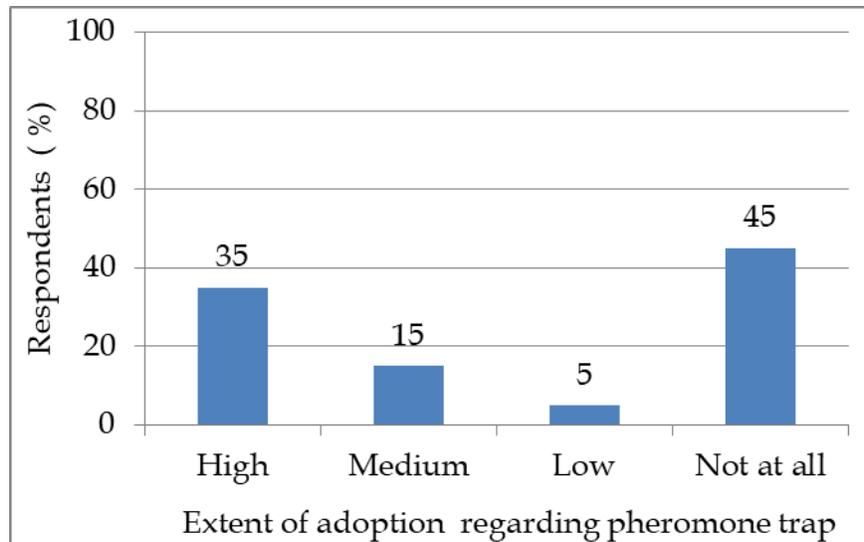


Figure 47 Extent of adoption regarding pheromone trap in Golapganj upazila

11.2.1.2.11. Light trap

Results revealed that only 13.3% of the respondents used light trap techniques in high level while 5% of them used it in low level and 81.6% of them did not use at all (Figure 48). As majority of the respondents did not use the light trap technique, necessary steps should be taken so that the farmers will adopt this technique as it is environmental friendly and beneficial to control harmful insects.

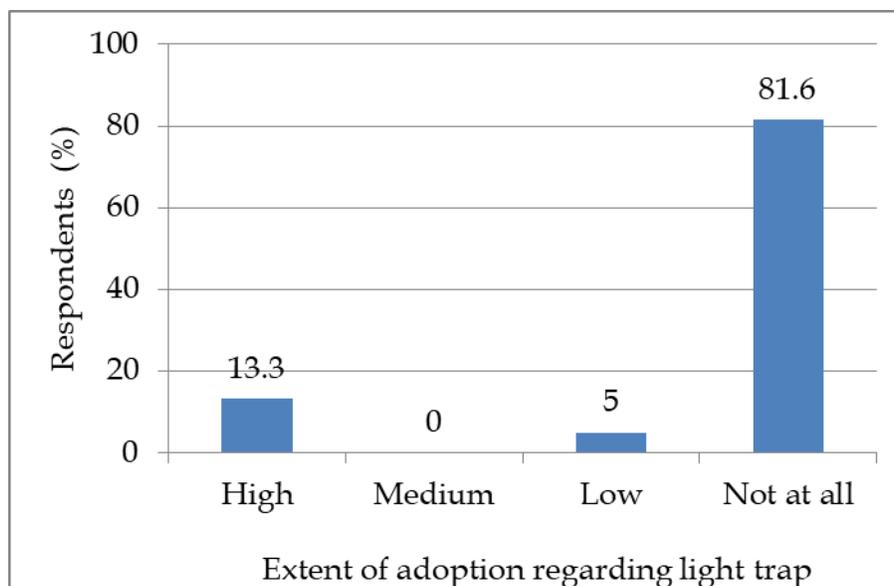


Figure 48 Extent of adoption regarding light trap in Golapganj upazila

11.2.1.2.12. Perching in paddy field

It was found that 63.3% of the respondents used perching technique in high level while 16.6% of them used it in medium level, 10% did in low level and 10% of them did not use at all (Figure 49). Necessary steps should be taken so that all of the farmers will adopt this technique as it is environmental friendly and beneficial to control insect pests.

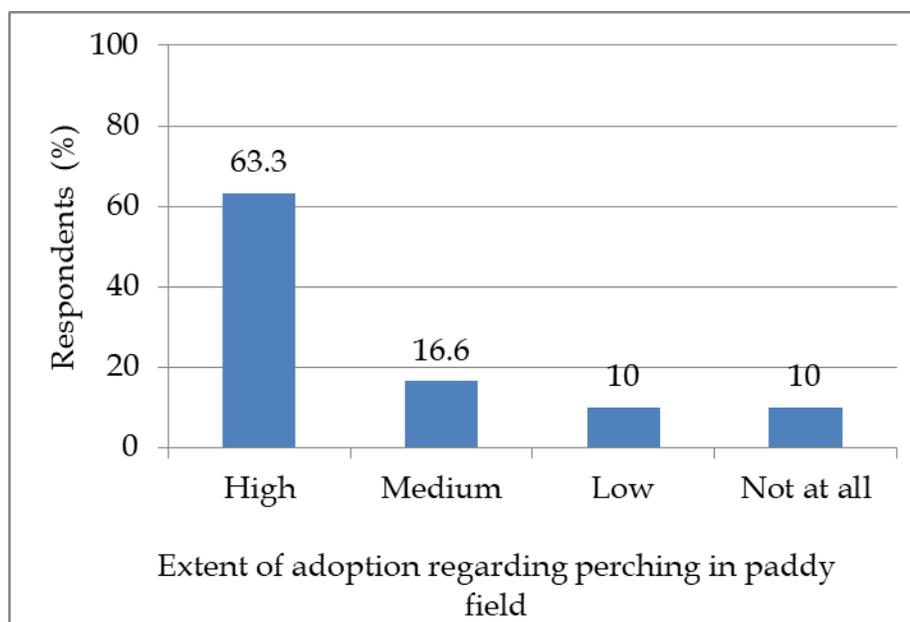


Figure 49 Extent of adoption regarding perching in paddy field in Golapganj upazila

11.2.1.2.13. Intercropping

It was found that 38.3% of the respondents adopted intercropping highly, 26.6% of them used this practice in medium level, 13.3% used it in low level while 21.6% of them did not adopt intercropping at all (Figure 50). As a large portion of the respondents do not adopt the practice, effort should be given for adopting intercropping in the study area to produce a greater yield on a given piece of land by making use of resources. Intercropping provides diversity and stability of fields as well as helps to suppress weeds and to reduce insect & disease infestation.

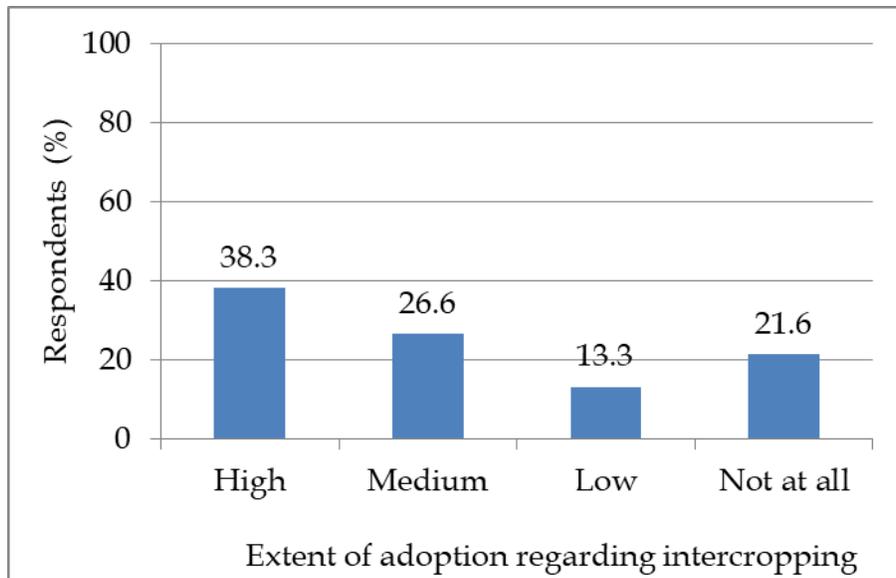


Figure 50 Extent of adoption regarding intercropping in Golapganj upazila

11.2.1.2.14 Agroforestry

It was found that 23.3% of the respondents adopted agroforestry in high level, 20% of them used it in medium level, 15% of them used it in low level while 41.6% of them did not adopt agroforestry at all (Figure 51). As a large portion of the respondents do not adopt the practice, effort should be given for adopting agroforestry in the study area which helps to maintain soil fertility at satisfactory level, to reduce soil erosion, to prevent water pollution and can lead to rise in productivity at low operational costs. In fact, agroforestry can lead to resilient and sustainable food production.

11.2.1.2.15 Alternate Wetting and Drying

It was found that 100% of the respondents did not use alternate wetting and drying (AWD) method at all (Figure 52). It is matter of regret that among the respondents, majority were not familiar with the term AWD and none had used it. So, it is mandatory to take necessary steps so that the farmers will adopt this technique as it is profitable, environmental friendly and beneficial. Training should be given to the farmers to introduce them with this technology, technical support also should be given so that they can adopt this technique in their field to reduce water loss and irrigation cost.

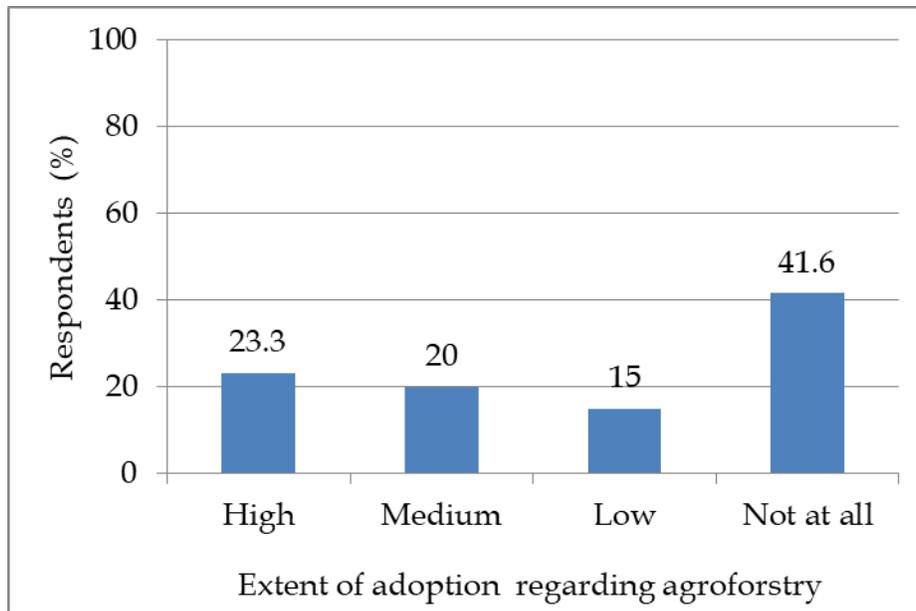


Figure 51 Extent of adoption regarding agroforestry in Golapganj upazila

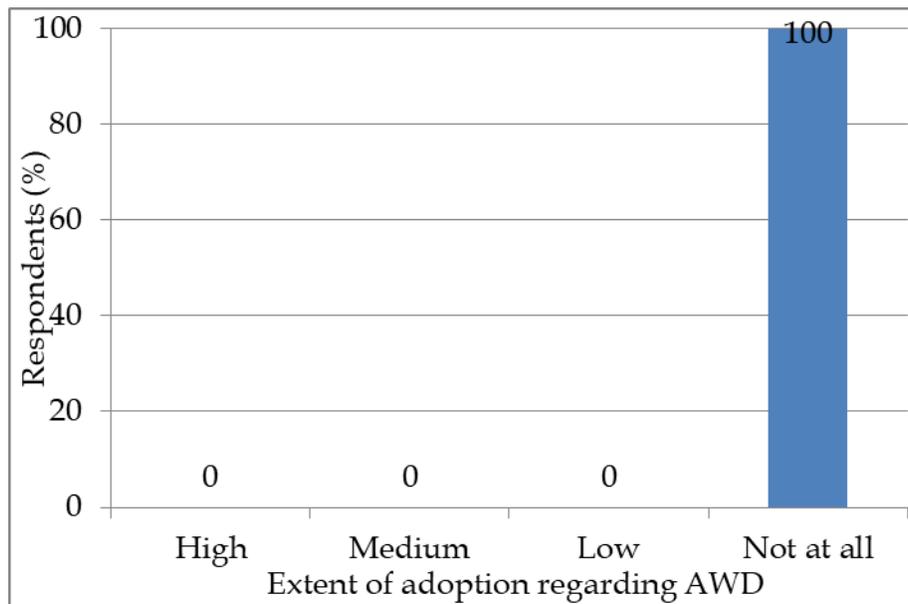


Figure 52 Extent of adoption regarding AWD in Golapganj upazila

11.2.1.2.16. Short duration varieties

It was reported that 46.6% of the respondents adopted short duration varieties in high level, 23.6% used it in medium level, 6.6% used it in low level while 23.6% of them did not adopt short duration varieties at all (Figure 53). As a large portion of the respondents do not adopt the practice, effort should be given for adopting short duration varieties in the study area. Shorter duration for maturity of crops helps in faster production of crops and such crops spend less time on field so expenditure on irrigation, pesticides are needed less compared to normal crops.

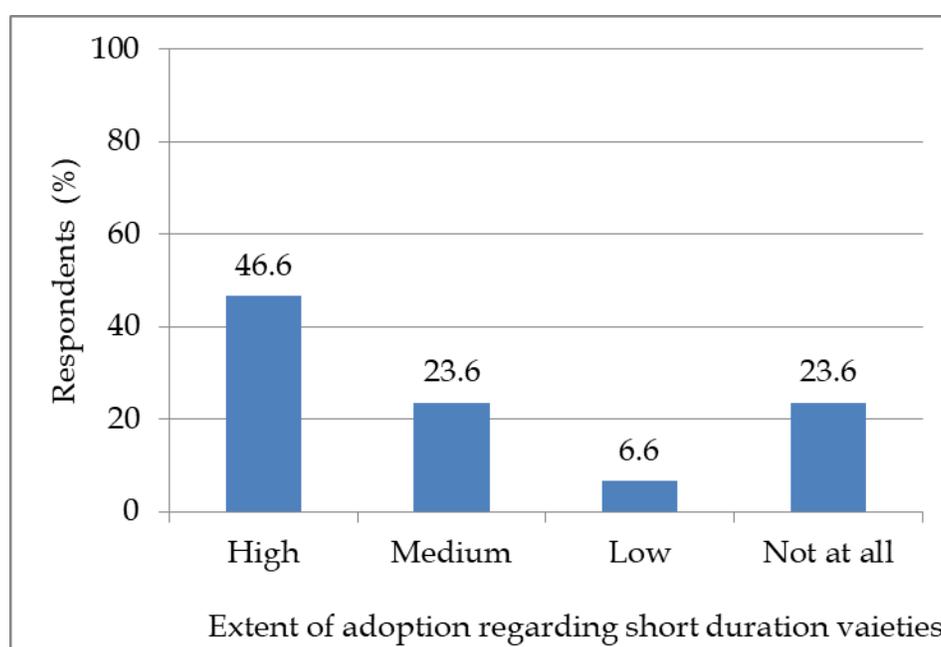


Figure 53 Extent of adoption regarding short duration varieties in Golapganj upazila

11.2.1.2.17. Sorjan method

It was found that 21.6% of the respondents adopted sorjan method in high level, 20% used it in medium level, 6.6% used it in low level while 51.6% of them did not adopt sorjan method at all (Figure 54). As a large portion of the respondents do not adopt the practice, effort should be given for adopting sorjan method in the study area to increase the productivity and to increase the soil fertility.

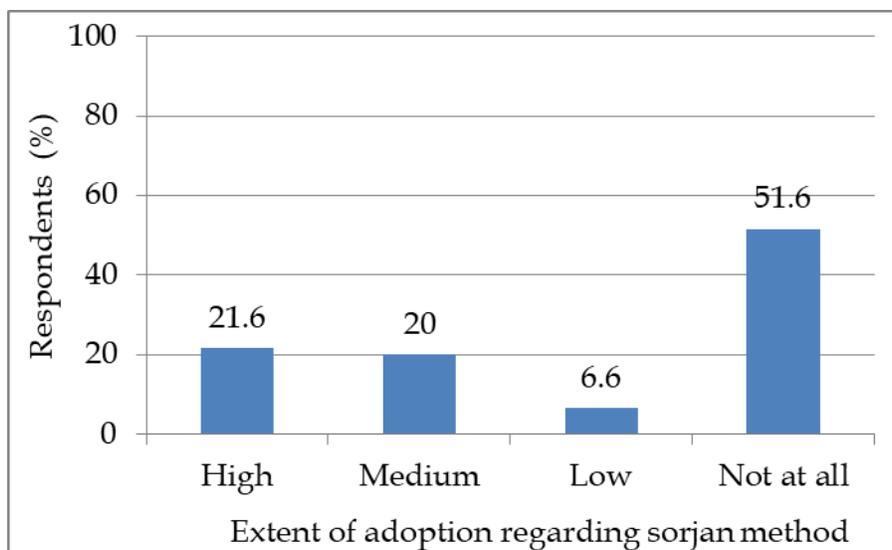


Figure 54 Extent of adoption regarding Sorjan method in Golapganj upazila

11.2.1.2.18. Use of local pesticides

It was found that 35% of the respondents used local pesticides highly, 21.6 % used it in medium level, 11.6% used it in low level while 31.6% of them did not adopt this technique at all (Figure 55). As a large portion of the respondents do not adopt the practice, effort should be given for adopting local pesticides in the study area to increase the productivity and to maintain the soil fertility at low cost of production.

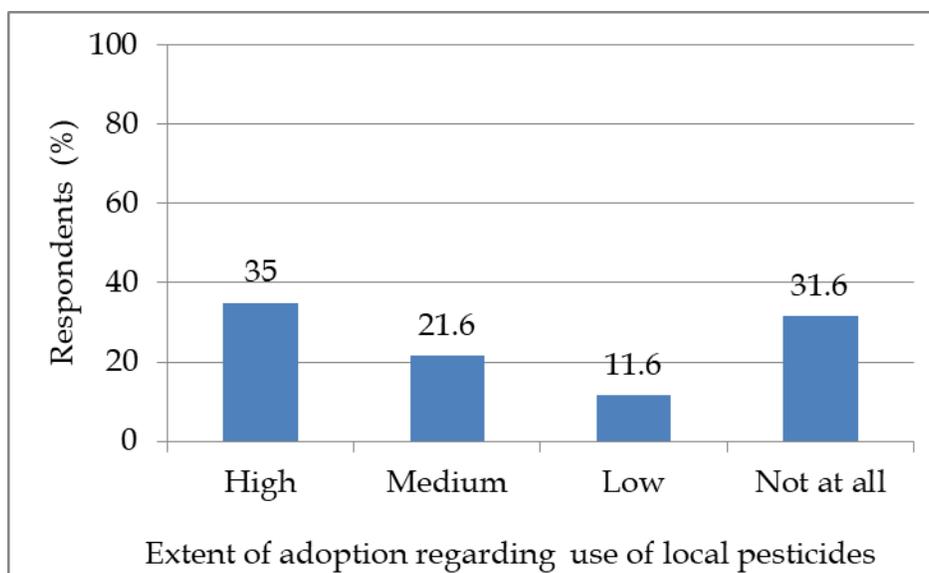


Figure 55 Extent of adoption regarding use of local pesticides in Golapganj upazila

11.2.1.3. Constraints in using climate smart agricultural practices

Respondents were asked about their constraints in Climate smart agricultural practices viz. lack of improved variety, improved livestock breed, technical knowledge, advice in proper time, training, incentives, capitals, irrigation water, farm inputs. The level of constraints was categorized into four category– very constraints, moderate constraints, low constraints and no opinion.

11.2.1.3.1. Lack of improved variety

It was reported that, 51.6% of the respondents had faced very constraints, 8% had faced moderate constraints, 13% had faced low constraints and 8% had no opinion (Figure 56). As a large portion of the respondents were facing very constraints, effort should be given on providing more improved variety to them. So that they can use this technique and can increase their production.

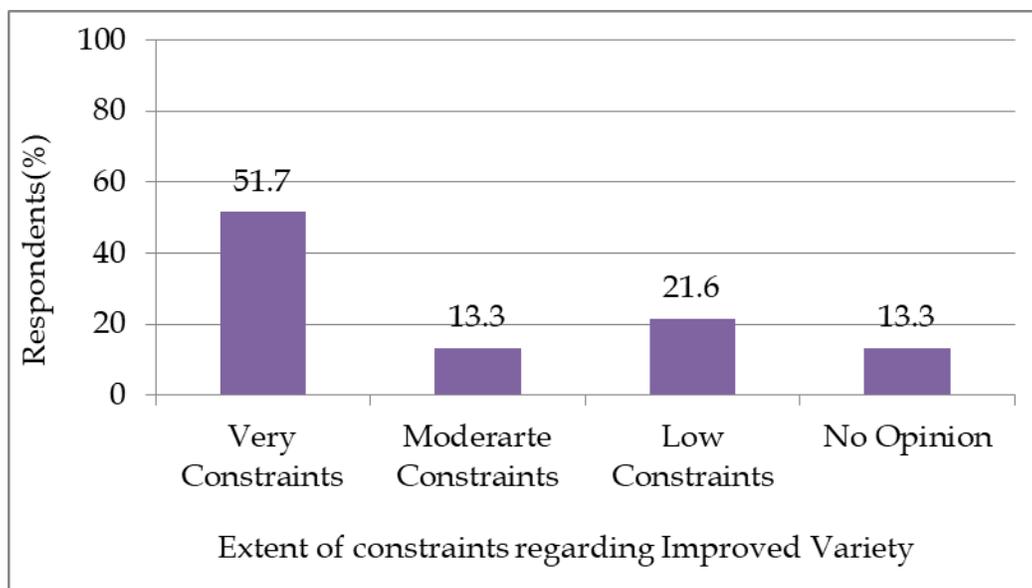


Figure 56 Extent of constraints regarding the improved variety in Golapganj upazila

11.2.1.3.2. Lack of improved livestock breed

It was reported that, 60.6% of the respondents faced very constraints, 15% faced moderate constraints, 10% faced low constraints and 8.3 % had no opinion regarding improved livestock breed (Figure 57). As a large portion of the respondents were facing very constraints, effort should be given on providing more improved livestock breed to them. So that they can use this technique and can improve their livelihood.

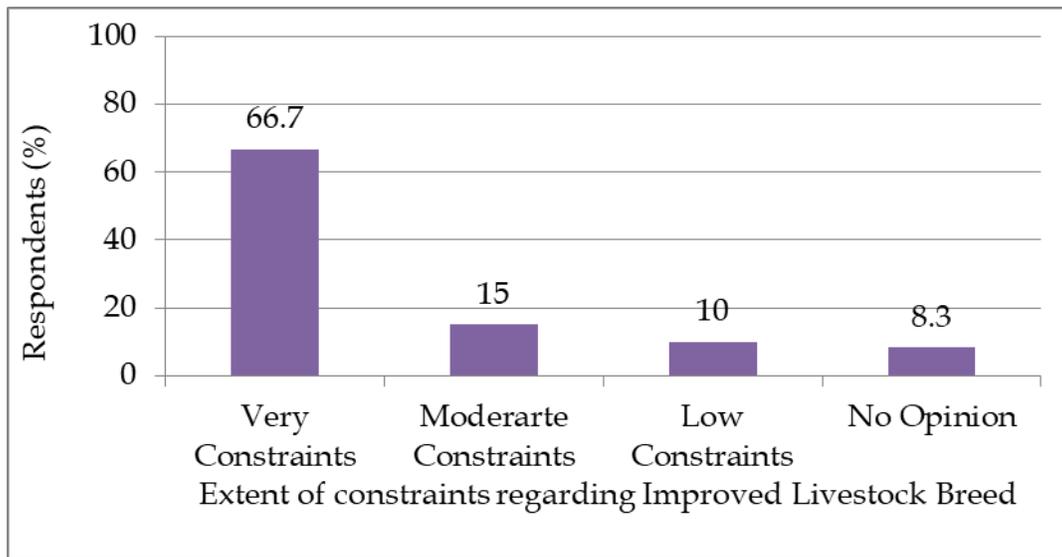


Figure 57 Extent of constraints regarding the livestock breed in Golapganj upazila

11.2.1.3.3. Lack of technical necessary knowledge

It was reported that, 56.6% of the respondents faced very constraints, 16.6% faced moderate constraints, 15% faced low constraints and 11.6% had no opinion (Figure 58). As a large portion of the respondents were facing very constraints, effort should be given on providing training related to technical knowledge to them. Thus they can increase their efficiency.

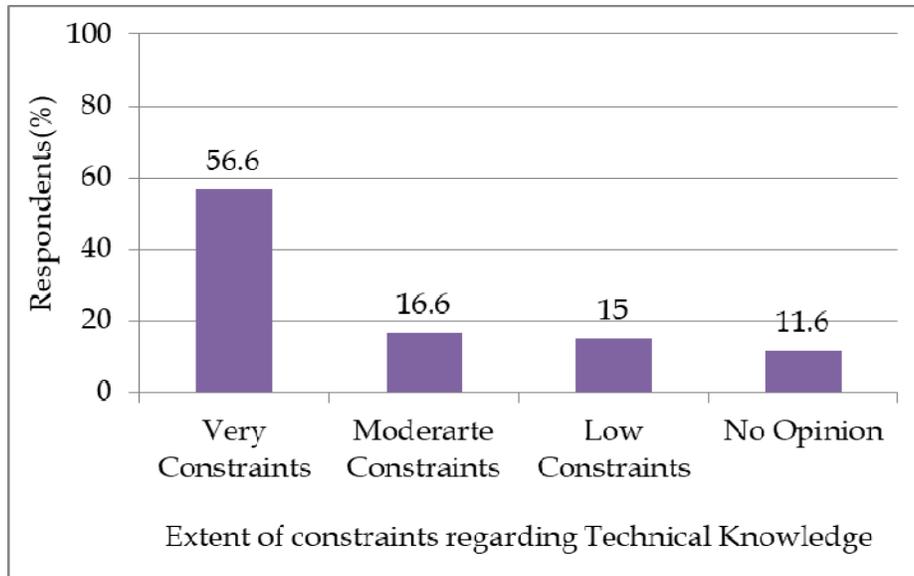


Figure 58 Extent of constraints regarding technical knowledge in Golapganj upazila

11.2.1.3.4. Lack of advice in proper time

It was reported that, 38.3% of the respondents faced very constraints, 18.3% faced moderate constraints, 16.6% faced low constraints and 26.6 % had no opinion (Figure 59). As a large portion of the respondents were facing very constraints, effort should be given on providing more appropriate advice to them. Thus they can use proper technique in proper time.

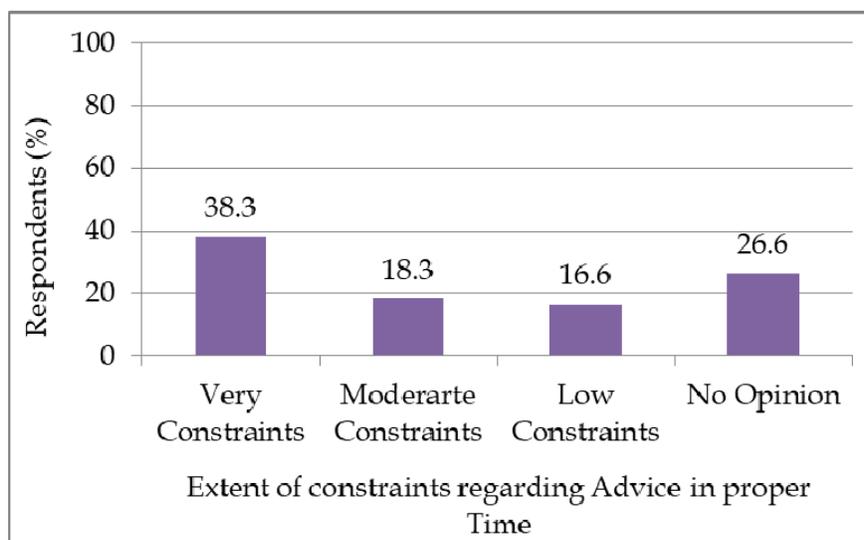


Figure 59 Extent of constraints regarding advice in proper time in Golapganj upazila

11.2.1.3.5. Lack of training

It was reported that, 28.3% of the respondents faced very constraints, 38.3% faced moderate constraints, 16.6% faced low constraints and 16.6 % had no opinion (Figure 60). As a large portion of the respondents were facing constraints, effort should be given on providing more training to them, so that they can know more information through training and implement those techniques in their farming systems.

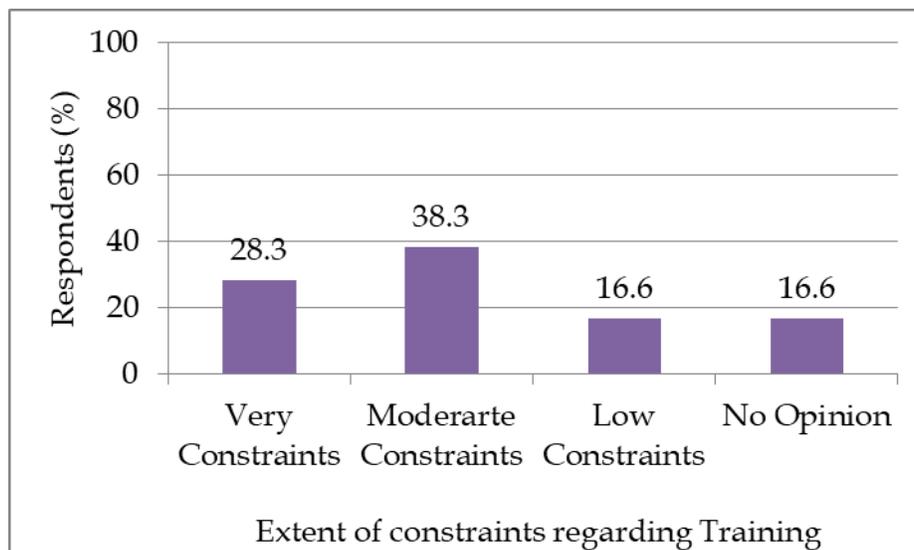


Figure 60 Extent of constraints regarding training in Golapganj upazila

11.2.1.3.6. Lack of incentives

It was reported that, 43.3% of the respondents faced very constraints, 8.3% faced moderate constraints, 15% faced low constraints and 33.3 % had no opinion regarding incentives (Figure 61). As a large portion of the respondents were facing very constraints, effort should be given on providing more incentives to them. So that they can use these incentives and can earn more profit.

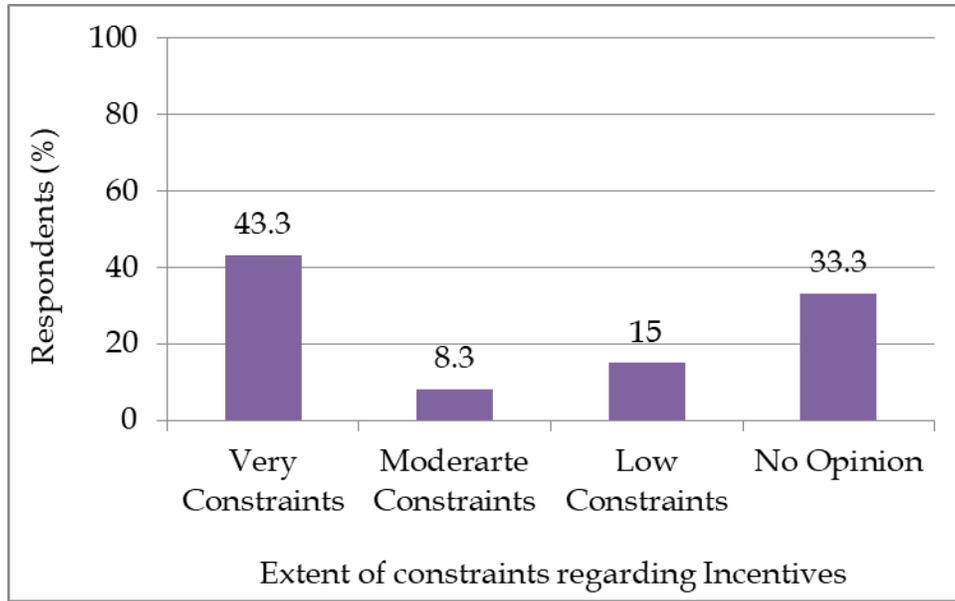


Figure 61 Extent of constraints regarding incentives in Golapganj upazila

11.2.1.3.7. Lack of capital

It was reported that, 56.6% of the respondents faced very constraints, 25% faced moderate constraints, 10% faced low constraints and 8.3 % had no opinion regarding capital (Figure 62). As a large portion of the respondents were facing very constraints, effort should be given on providing bank loan with lower rate of interest to them which could be used as their capital & they could improve their livelihood.

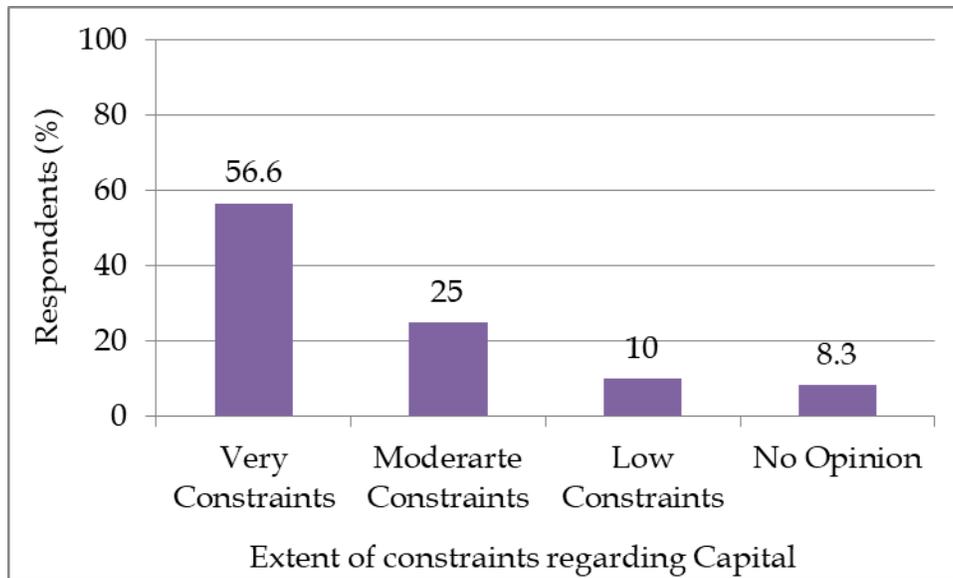


Figure 62 Extent of constraints regarding capital in Golapganj upazila

11.2.1.3.8. Lack of irrigation water

It was reported that, 25% of the respondents faced very constraints, 25% faced moderate constraints, 16.6% faced low constraints and 33.3% had no opinion (Figure 63). As a large portion of the respondents were facing very constraints, effort should be given on providing more irrigation facilities to them, so that they don't have to face irrigation problems.

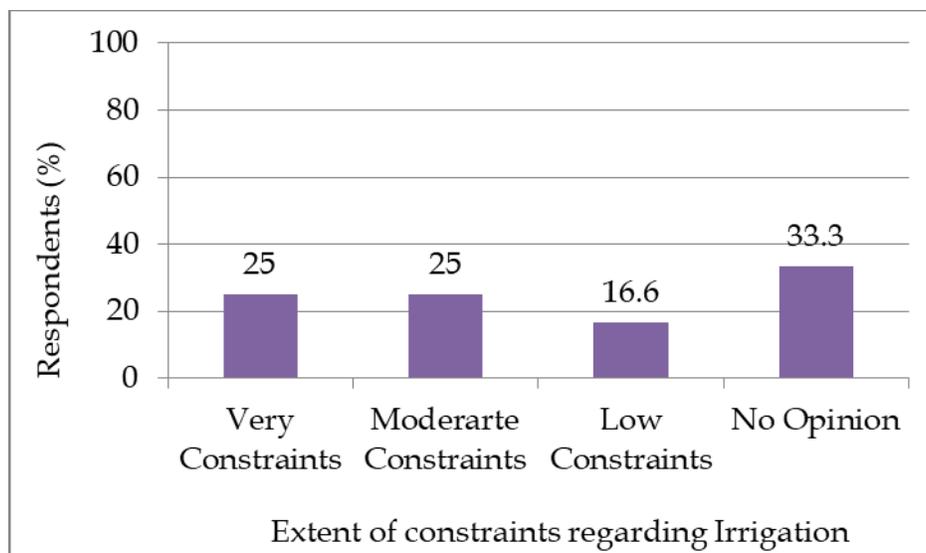


Figure 63 Extent of constraints regarding irrigation in Golapganj upazila

11.2.1.3.9. Unavailability of farm inputs

It was reported that, 43.3% of the respondents faced very constraints, 18.3% faced moderate constraints, 11.6% faced low constraints and 26.6 % had no opinion (Figure 64). As a large portion of the respondents were facing very constraints, effort should be given on providing more farm inputs to them. So that they can use those farm inputs and can make their farming activity easy.

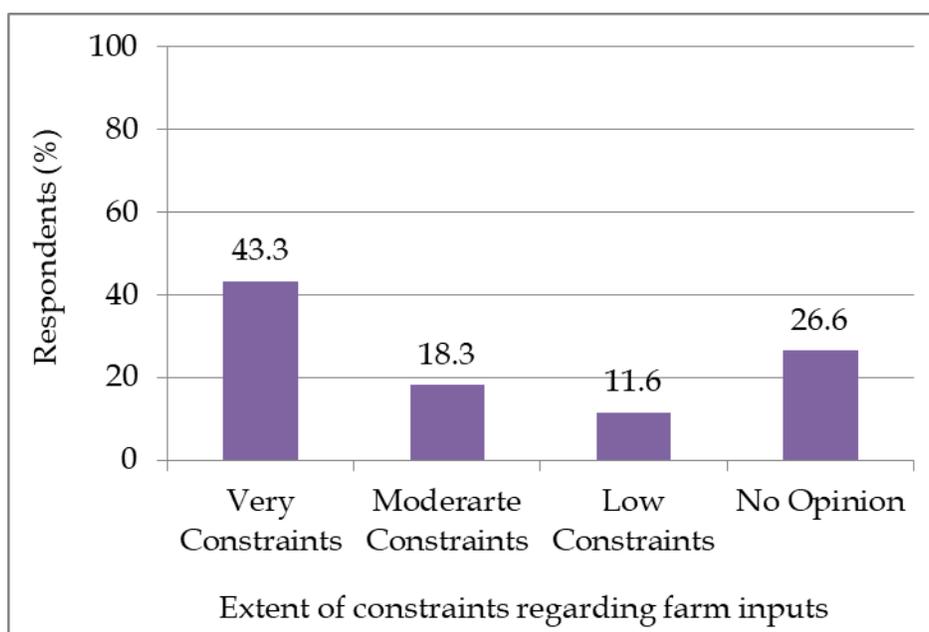


Figure 64 Extent of constraints regarding farm inputs in Golapganj upazila

11.2.1.4. Pools of existing CSA practices

Paudel *et al.* (2017) reported six pools of CSA options as carbon smart, nutrient smart, water smart, weather smart, knowledge smart and energy smart. But, practices under the energy smart pool were not found. In addition, a new pool as “pest smart” was proposed. As a result, existing seventeen CSA practices of Golapganj upazila were also categorized into six pools viz. pest smart, carbon smart, nutrient smart, water smart, weather smart and knowledge smart. These pools are shown in table 49.

Table 49 Pools of existing Climate Smart Agricultural practices in Golapganj upazila of Sylhet district

Pools	Existing practices
Pest smart	Perching, IPM, Crop rotation, Pheromone trap, Light trap, Use of local pesticide
Carbon smart	Zero tillage, Rice-cum-fish farming
Nutrient smart	Farm yard manuring , Vermicomposting, Agroforestry
Water smart	Water harvesting, Sorjan method, Mulching
Weather smart	Adjusting planting time
Knowledge smart	High yielding varieties, Adjusting planting time, Improved livestock breed, Short duration varieties, Intercropping

11.2.1.5. Attributes of existing practices under CSA framework

Seventeen CSA practices were reported in the study area. Attributes of existing practices under CSA framework are sustainably increasing agricultural productivity, adapting & building resilience to climate change and opportunities to reduce GHG emissions. These are shown in table 50

Table 50 Attributes of existing CSA practices at Golapganj upazila

Existing practices	Attributes of the existing CSA practices		
	Sustainably increasing agricultural productivity	Adapting and building resilience to climate change	Opportunities to reduce GHG emissions
High yielding variety	√		
Improved livestock	√	√	
Adjusting planting time		√	
Crop rotation		√	
Mulching	√	√	
Vermicomposting	√		√
Farm yard manuring	√		
Rice-cum-fish farming	√		√
Integrated pest management (IPM)	√	√	
Pheromone trap	√	√	
Light trap	√		

Existing practices	Attributes of the existing CSA practices		
	Sustainably increasing agricultural productivity	Adapting and building resilience to climate change	Opportunities to reduce GHG emissions
Perching	√	√	
Intercropping	√	√	√
Agroforestry	√	√	
Short duration varieties	√	√	
Sorjan method		√	
Use of local pesticides	√		√

11.2.1.6. Key challenges associated with adopting CSA Practices

It was reported that there were some challenges associated with adopting existing CSA practices in the study area. Challenges associated with adopting existing CSA practices are shown in table 51.

Table 51 Challenges associated with adopting existing CSA practices at Golapganj upazila of Sylhet district

CSA Practices	Challenges reported
High yielding varieties	Poor quality and higher price of HYV. Pest and disease susceptibility.
Improved livestock	Quality, price and unavailability of new breeds.
Adjusting planting time	Lack of information.
Crop rotation	Lack of information.
Mulching	Lack of information.
Vermicomposting	Lack of information and skill.
Farm yard manuring	Lack of proper knowledge and skill.
Rice-cum-fice farming	Lack of proper knowledge and skill.
IPM	Lack of proper knowledge and skill.
Pheromone trap	Lack of proper knowledge and skill.
Light trap	Lack of proper knowledge and skill.
Perching	Initial cost.
Intercropping	Lack of information.
Agroforestry	Insufficient information and lack of skill.
Short duration varieties	Lack of information and availability.
Sorjan method	Lack of information.
Use of local pesticides	Lack of information and supply.

11.2.1.7. Proposed approach for up-scaling potential CSA options

A three-tier up-scaling approach was proposed consisting of different time scale for the study area. Proposed approach for up-scaling potential CSA options is shown in table 52.

Table 52 Proposed approaches for up-scaling potential CSA options at Golapganj upazila of Sylhet district

Up-scaling Approach	Examples of proposed CSA options	Time scale	Role of contributors
Information-transfer approach	Community seed banks, Vertical drainage, pH management, Sandbar cropping, Rice-cum-fish farming, Case-fish farming, Farmer managed natural regeneration, Agroforestry, etc.	Short term	Support for extension and information dissemination through demonstration and training with financial incentives to target local community.
Entrepreneur development approach	Biochar, Water saving laser land leveling, Improved cook stoves etc.	Short and/or mid term	Attract entrepreneur by providing financial support and removing barriers.
Policy inclusion approach	Solar based irrigation, Agricultural insurance, Site specific real time based agro-advisory services and weather forecasts, Incentive for CSA practices etc.	Long term	Framing the situation, describing the dynamics and synthesizing the understanding into policy framework for priority and investment

11.2.2. Jaintiapur upazila

11.2.2.1. Farmers' Perceptions on Experiencing Climate Change

Respondents were categorized into two groups according to their perceptions on experiencing climate change viz. perceived & not perceived. Distribution of the farmers according to their perception on experiencing climate change is shown in figure 65.

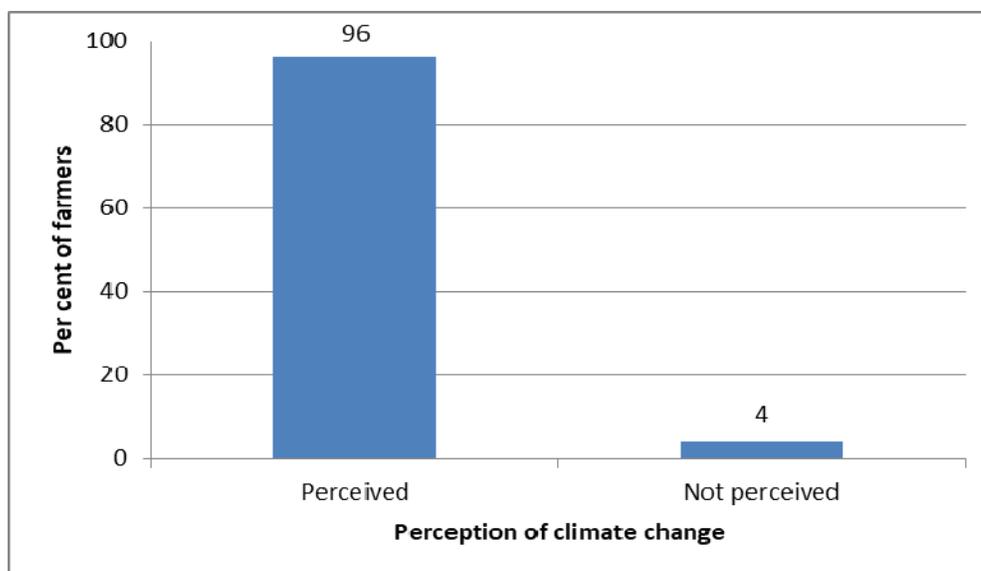


Figure 65 Distribution of the farmers according to their perception on experiencing climate Change

11.2.2.1.1. Perceived changes in specific climatic events

To know the respondent's perceived changes, the extent of changes in specific climatic events were categorized as increased, decreased, no change and don't know. Distribution of the farmers according to their perceived changes in specific climatic events is shown in table 53.

Table 53 Distribution of the farmers according to their perceived changes in specific climatic events

Climatic event	% of farmers			
	Increased	Decreased	No change	Don't know
Temperature in summer season	63	25	10	2
Temperature in winter season	58	29	13	0
Amount of rainfall	42	48	10	0
Uneven distribution of rainfall	59	14	17	11
Drought length and severity	48	25	22	5
Hailstorm amount and severity	58	30	7	5
Lightening	54	34	9	3

11.2.2.2. Existing CSA practices

In the study area the farmers practice nineteen CSA practices viz. perching, high yielding varieties, adjusting planting time, farm yard manure, green manuring, crop rotation, vermicomposting, cover crop, fallowing, rain water harvesting, alternate wetting and drying (AWD), improved livestock breed, community seed bed, urea super granule (USG), integrated pest management (IPM), sorjon method, floating bed fodder, zero tillage and raised bed planting. Distribution of the farmers according to CSA practices they follow is shown in figure 66.

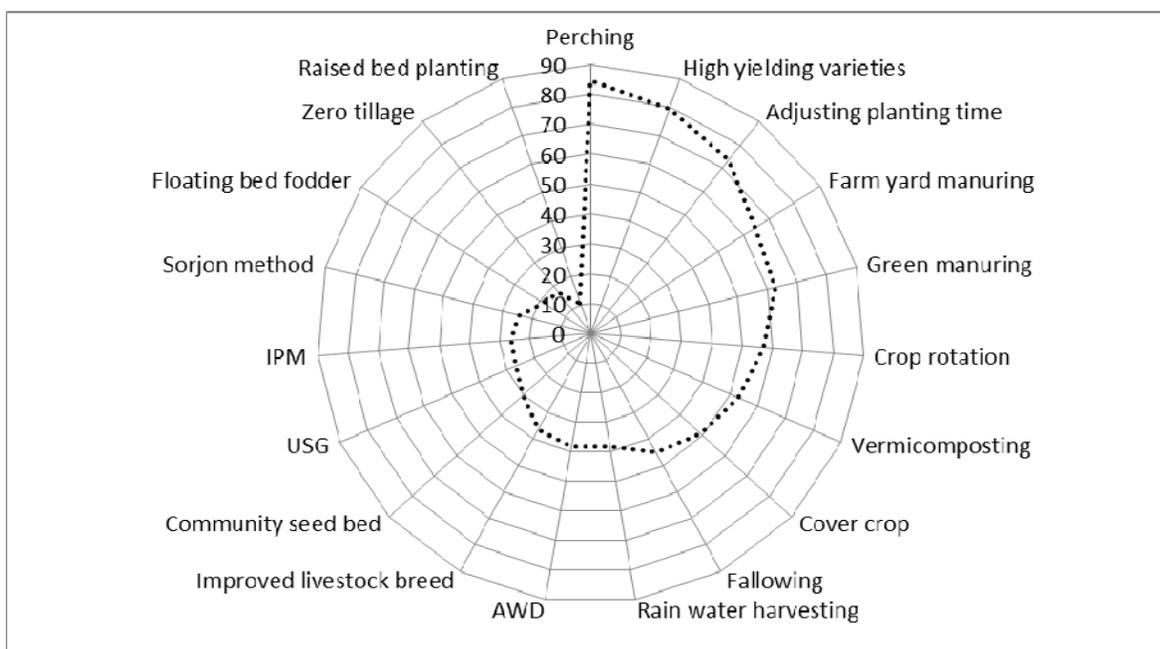


Figure 66 Existing CSA practices in the study area

12.2.2.2.1. Pools of existing CSA practices

Jaintiapur upazila was categorized into six pools viz. pest smart, carbon smart, nutrient smart, water smart, weather smart and knowledge smart. These pools are shown in table 54.

Table 54 Pools of existing CSA practices

Pools	Existing practices
Pest smart	Perching, IPM, Crop rotation
Carbon smart	Zero tillage, USG, AWD
Nutrient smart	Farm yard manuring, Green manuring, Vermicomposting
Water smart	Cover crop, rain water harvesting, AWD, Sorjon method, Floating bed planting
Weather smart	Adjusting planting time
Knowledge smart	High yielding varieties, Adjusting planting time, Improved livestock breed, Community seed bed

11.2.2.2.2. Attributes of existing practices under CSA framework

Nineteen CSA practices were reported in the study area. Attributes of existing practices under CSA framework are shown in table 55.

Table 55 Attributes of existing CSA practices at Jaintiapur upazila

Existing practices	Attributes of the existing CSA practices		
	Sustainably increasing agricultural productivity	Adapting and building resilience to climate change	Opportunities to reduce GHG emissions
Perching	√	√	
High yielding varieties	√	√	
Adjusting planting time	√	√	
Farm yard manuring	√	√	
Green manuring	√	√	
Crop rotation	√	√	√
Vermicomposting	√	√	
Cover crop	√	√	√
Fallowing	√	√	
Rain water harvesting	√	√	
AWD	√		√
Improved livestock breed	√	√	√
Community seed bed	√	√	
USG	√		√
IPM	√	√	
Sorjon method	√	√	√
Floating bed fodder	√	√	√
Zero tillage		√	√
Raised bed planting	√	√	√

11.2.2.2.3. Key challenges Associated with adopting CSA Practices

It was reported that there were some challenges associated with adopting existing CSA practices in the study area. Challenges associated with adopting existing CSA practices are shown in table 56.

Table 56 Challenges associated with adopting existing CSA practices

CSA Practices	Challenges reported
Perching	Initial cost.
High yielding varieties	Lower quality and higher price of HYV. Pest and disease susceptibility.
INM	Lack of proper knowledge and skill.
Adjusting planting time	Lack of information.
Farm yard manuring	Lack of proper knowledge and skill.
Green manuring	Lack of information.
Crop rotation	Lack of information.
Vermicomposting	Lack of information and skill.
Cover crop	Unavailability of proper material.
Fallowing	Lack of information.
Rain water harvesting	Insufficient information and lack of infrastructure for collecting rain water.
AWD	Lack of skill and unreliable irrigation source
Improved livestock breed	Quality, price and unavailability of new breeds.
Community seed bed	Lack of information.
USG	Lack of information and supply.
IPM	Insufficient knowledge and skill.
Sorjon method	Lack of information and skill.
Floating bed fodder	Lack of information.
Zero tillage	Lack of information.
Raised bed planting	Lack of information.

11.2.2.2.4. Proposed approach for up-scaling potential CSA options

A three-tier up-scaling approach was proposed consisting of different time scale for the study area. Proposed approach for up-scaling potential CSA options is shown in table 57.

Table 57 Proposed approaches for up-scaling potential CSA options

Up-scaling approach	Examples of proposed CSA options	Time scale	Role of contributors
Information-transfer approach	Community seed banks, Vertical drainage, pH management, Sandbar cropping, Rice-cum-fish farming, Case-fish farming, Farmer managed natural	Short term	Support for extension and information dissemination through demonstration and training with financial

Up-scaling approach	Examples of proposed CSA options	Time scale	Role of contributors
	regeneration, Agroforestry, etc.		incentives to target local community
Entrepreneur development approach	Biochar, Water saving laser land leveling, Improved cook stoves etc.	Short and/or mid term	Attract entrepreneur by providing financial support and removing barriers.
Policy inclusion approach	Solar based irrigation, Agricultural insurance, Site specific real time based agro-advisory services and weather forecasts, Incentive for CSA practices etc.	Long term	Framing the situation, describing the dynamics and synthesizing the understanding into policy framework for priority and investment

11.3. Study 3: Evaluation of agar based agroforestry practices.

11.3.1. Performance of agar tree

To know the growth performance in terms of plant height (m), girth at breast height (GBH) in cm, girth at base (cm), girth at middle (cm), girth at collar (cm) and diameter at breast height (DBH) in cm of agar under sole and different agroforestry systems in association with pineapple, malta, ginger, tea, turmeric and bilati dhonia were measured at the initial and end of the experimentation. First measurement was done in February 2018 and final measurement was done in August 2018. A comparison of the performance of agar between sole and different agroforestry system has been demonstrated in Table 58. All the parameters of agar did not vary significantly between sole cultivation and under different agroforestry systems. However, height of agar trees increased in most of the agroforestry systems except malta and turmeric agroforestry systems compared to sole cultivation. GBH, girth at middle and girth at collar increased in the all the agroforestry systems compared to sole cultivation. Girth at base and

DBH increased most of the agroforestry system except only malta agroforestry system compared to sole cultivation.

Table 58 Performance of Agar trees in both monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters					
	Height (m)	GBH (cm)	Girth at base (cm)	Girth at middle (cm)	Girth at collar (cm)	DBH(cm)
Agar sole	4.03	13.34	23.78	15.53	12.12	4.16
Agar + Pineapple	4.21	14.62	27.29	17.72	13.82	4.65
Agar + Malta	3.86	13.64	23.57	16.38	12.82	4.11
Agar + Ginger	4.21	15.13	29.00	19.77	13.99	4.81
Agar + Tea	4.30	16.40	32.84	20.29	15.28	5.08
Agar + Turmeric	4.02	13.44	31.42	16.87	13.29	4.27
Agar + Bilati dhonia	4.43	15.81	29.99	17.41	15.67	5.03
CV (%)	11.06	18.45	26.62	18.00	16.046	17.48
LSD	0.82	4.80	13.38	5.67	3.95	1.427
SL	NS	NS	NS	NS	NS	NS

11.3.2. Performance of Malta

For understanding the initial growth performance in terms of plant height (cm), number of branches, number of leaves, stem diameter (mm), canopy (N-S) and canopy (E-W) in cm of malta under sole and agar based agroforestry system were measured at every month during the experimentation. A comparison of the performance of malta between sole and under agroforestry system has been demonstrated in Table 59. The height, number of branch and leaves of malta did not vary significantly in sole and agroforestry system. But the sole and agroforestry system showed significant ($P < 0.05$) differences in both north-south and east-west direction of malta canopy. North-south and east-west direction of malta canopy significantly creased in agroforestry systems. However, height and number of branch and leaves of malta also increased in the agroforestry systems compared to sole cultivation although not significant.

Table 59 Performance of malta in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters					
	Height (cm)	No. of branch	No. of leaf	Stem diameter (mm)	Canopy (N-S) in cm	Canopy (E-W) in cm
Sole	59.65	5.11	35.33	6.27	28.13a	28.55a
Agroforestry	62.62	6.11	49.33	5.68	27.30b	25.32b
CV (%)	5.911	31.73	34.74	202.93	0.44	2.98
LSD	12.69	6.25	51.66	42.56	0.42	2.82
SL	NS	NS	NS	NS		

11.3.3. Performance of Pineapple

For understanding the initial growth performance in terms of number of leaves, canopy (N-S) and canopy (E-W) in cm of pineapple under sole and agar based agroforestry system were measured at every month during the experimentation. A comparison of the performance of pineapple between sole and under agroforestry system has been demonstrated in Table 60. All the growth parameters of pineapple did not vary significantly between sole cultivation and under agroforestry systems. However, most of the parameters of pineapple increased in the agroforestry systems except north-south canopy compared to sole cultivation.

Table 60 Performance of Pineapple in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters		
	No. of leaf	Canopy (N-S) in cm	Canopy (E-W) in cm
Sole	21.11	85.82	70.29
Agroforestry	24.55	66.38	91.60
CV (%)	11.38	23.09	18.17
LSD	9.123	61.72	51.66
SL	NS	NS	NS

11.3.4. Performance of Tea

For understanding the initial growth performance in terms of plant height (cm), number of branches, number of leaves, stem diameter (mm), canopy (N-S) and canopy (E-W) in cm of tea under sole and agar based agroforestry system were measured at every month during the

experimentation. A comparison of the performance of tea between sole and under agroforestry system has been demonstrated in Table 61. The height, number of leaves and east-west canopy of tea did not vary significantly under sole and agroforestry system. But the sole and agroforestry system showed significant ($P < 0.05$) differences in number of branches, stem diameter and north-south canopy of tea. Number of branches, stem diameter and north-south canopy of tea significantly increased in agroforestry systems compared to its sole cultivation.

Table 61 Performance of tea in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters					
	Height (cm)	No. of Branch	No. of leaf	Canopy (N-S) in cm	Canopy (E-W) in cm	Stem diameter (mm)
Sole	79.65	2.00b	15.70	20.45b	18.20	2.89b
Agroforestry	86.61	3.58a	39.92	31.43a	29.73	5.69a
CV (%)	4.32	3.65	29.28	10.87	22.83	7.96
LSD	12.61	0.35	28.61	9.91	19.22	1.19
SL	NS		NS		NS	

However, the height, number of leaves and east-west canopy of tea did not vary significantly under sole and agroforestry system. But the height, number of leaves and east-west canopy of tea also increased in the agroforestry systems compared to sole cultivation.

11.3.5. Performance of Turmeric

For understanding the initial growth performance in terms of plant height (cm), number of leaves, north-south and east-west canopy in cm of turmeric under sole and agar based agroforestry system were measured at every month during the experimentation. A comparison of the performance of turmeric between sole and under agroforestry system has been demonstrated in Table 62. The height, number of leaves and both direction of canopy of turmeric did not vary significantly in sole and agroforestry system. However, height and number of leaves and north-south canopy higher in the sole cultivation systems compared to agroforestry system except east-west canopy of turmeric.

Table 62 Growth performance of turmeric in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters			
	Height (cm)	No. of Leaf	Canopy (N-S) in cm	Canopy (E-W) in cm
Sole	43.85	7.00	29.44	23.73
Agroforestry	42.53	4.88	22.51	26.73
CV (%)	17.46	29.77	18.74	25.51
LSD	26.49	6.212	17.11	22.61
SL	NS	NS	NS	NS

For evaluation of yield performance, weight and number of rhizome and number of finger of turmeric under sole and agar based agroforestry system were measured. A comparison of the performance of yield parameters of turmeric between sole and agroforestry system has been documented in table 63. The weight and number of rhizome of turmeric did not vary significantly in sole and agroforestry system. But the sole and agroforestry system showed significant ($P < 0.05$) differences in number of finger of turmeric. Finger number of turmeric significantly lower in agroforestry system. Moreover, weight and number of rhizome of turmeric also decreased in the agroforestry systems compared to sole cultivation although not significant.

Table 63 Yield performance of turmeric in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters		
	Weight	No. Rhizome	No. finger
Sole	2262	52.00	96.00a
Agroforestry	164	5.33	13.33b
CV (%)	54.73	71.59	39.18
LSD	2332.37	72.09	75.24
SL	NS	NS	

11.3.6 Performance of Ginger

For understanding the initial growth performance in terms of plant height (cm), number of leaves, north-south and east-west canopy in cm of ginger under sole and agar based agroforestry system were measured at every month during the experimentation. A comparison

of the performance of ginger between sole and under agroforestry system has been demonstrated in Table 64. The height and both direction of canopy of ginger did not vary significantly between sole and agroforestry system. But the sole and agroforestry system showed significant ($P<0.05$) differences in number of leaves of ginger. Number of leaves was significantly higher in agroforestry system than its sole cultivation.

Table 64 Growth performance of ginger in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters			
	Height (cm)	No. of Leaf	Canopy (N-S) in cm	Canopy (E-W) in cm
Sole	45.24	17.06b	30.36	19.47
Agroforestry	48.02	27.78a	29.98	30.29
CV (%)	1.69	11.36	13.08	29.69
LSD	2.78	8.94	13.87	25.95
SL	NS		NS	Ns

For evaluation of yield performance, weight and number of rhizome and number of finger of ginger under sole and agar based agroforestry system were measured. A comparison of the performance of yield parameters of ginger between sole and agroforestry system has been documented in table 65. The weight, number of rhizome and number of finger of ginger did not vary significantly in sole and agroforestry system.

Table 65 Yield performance of ginger in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters		
	Weight	No. Rhizome	No. finger
Sole	276.12	6.6	25.30
Agroforestry	290.67	6	18.33
CV (%)	1.61	2.97	28.72
LSD	15.98	0.66	22.02
SL	NS	NS	NS

11.3.7. Performance of Bilati Dhonia

For understanding the initial growth and yield performance in terms of plant height (cm), number of leaves, root length (cm), total weight (g), root weight (g), shoot weight (g) and root/shoot ratio of bilati dhonia were measured at harvesting.



Figure 67 Bilati dhonia at harvest

A comparison of the performance of bilatidhonia between sole and under agroforestry system has been demonstrated in Table 66. All the growth and yield parameters did not vary significantly between sole and agroforestry system. However, most of the parameters insignificantly higher in agroforestry system compared to its sole cultivation except root/shot ratio.

Table 66 Yield performance of bilati dhonia in monoculture and agroforestry system in Barlekha of Moulvibazar district.

Systems	Parameters						
	Height (cm)	Root length (cm)	No. of Leaf	Total weight (g)	root weight (g)	Shoot weight (g)	Root /shot ratio
Sole	17.67	3.33	3.67	3.07	0.97	1.73	0.55
Agroforestry	21.00	4.50	6.00	9.27	2.80	5.87	0.41
CV (%)	23.5143	10.42	16.89	51.03	66.14	46.53	9.00
LSD	15.9709	1.43	2.87	11.05	4.38	6.21	0.15
SL	NS	NS	NS	NS	Ns	NS	NS

11.3.8. Nutrient status of initial and final soil under sole and agroforestry system

Initial and post-harvest soils were analyzed to see the status of initial and end of the experiment which has been showed in Table 67. The table is showing the change of soil characteristics due to cultivation. There was no significant change in the soil nutrient status. The pH of the soil was slightly increased in both of the case. Organic Matter of the soil increased due to litter fall. Slight reduction occurred in case of other macronutrient like N, K, Ca, Mg, P, S, B, Cu and Mn. The amount of Fe increased in the plots under both systems.

Table 67 Soil nutrient status of field under sole and agroforestry system

Elements	Sole		Agroforestry System	
	Initial	Final	Initial	Final
pH	5.61	5.89	4.72	4.96
Total N (%)	0.071	0.0568	0.94	0.8648
OM (%)	1.21	1.3915	1.62	1.863
K (meq/100g)	0.14	0.133	0.09	0.099
Ca (meq/100g)	0.73	0.6935	0.26	0.247
Mg (meq/100g)	0.29	0.2775	0.25	0.2375
P(ug/g soil)	5.27	5.0065	5.25	4.9875
S(ug/g soil)	28.5	27.075	21.5	20.425
B(ug/g soil)	1.02	0.969	0.92	0.874
Zn (ug/g soil)	5.14	4.883	1.62	1.539
Cu (ug/g soil)	0.35	0.3325	0.48	0.456
Fe(ug/g soil)	78	81.9	123	129.15
Mn (ug/g soil)	5	4.75	2	1.9

11.4 Discussion

Farmers were involved in different production activities viz. homestead agroforestry, livestock, field crop production, roadside agroforestry, citrus based agroforestry, aqua forestry, pineapple based agroforestry, cropland agroforestry, betel leaf agroforestry, black pepper based agroforestry, drumstick production, apiculture, agar plantation and others production practices. Among the production activities most of the respondents were involved in rice cultivation, guava cultivation, vegetable cultivation, betel nut cultivation, livestock (Cattle, pasture, poultry, Turkey, titir) etc. But here berry, toikor, satkora are neglected and underutilized species which have a huge research scope as Sylhet district is good for citrus cultivation. Rashid *et al.* (2007) found eleven different traditional agroforestry practices in Pabna district.

Diversified plant species were observed in both the study area. Total 86 plant species were recorded in Golapgonj upazila and 97 plant species were reported in Jantiapur upazila of Sylhet district. Among homestead, vegetable, medicinal, spice species jackfruit (85%), lemon (66.67%), country bean (0.15%), sweet gourd (0.13%), neem (41.67%), khude thankuni (36.67%), bay leaf (51.67%), green chilli (50%), nagamorich (41.67%) were grown by most of the respondents in the study area. Besides this some new crop and tree species are being cultivated in the study area such as HYV tomato, sweet gourd, mangium, guava etc. and they are high in number. Almost all the people are engaged in rice cultivation. On the other hand, wood apple, lukluki, capsicum, sweet potato, pathorkuchi, longevity spinach, ginger, turmeric etc. are grown less in the study area. Similar type of timber species diversity was observed by Sadaat (2007) in Gaibandha and he observed total 21 timber species in his study area. Similar type of medicinal species diversity was observed by Yasmin *et al.* (2010) at Tangail and they observed total 35 medicinal species.

In Golapgonj upazila, it is found that among the eighteen existing CSA practices- high yielding varieties (78.3%), perching (63.3%), adjusting planting time (51.6%) are being practiced by the farmers largely. On the other hand, less adopted practices are improved livestock breed (25%), crop rotation (38.3%), mulching (46.6%), vermicomposting (23.3%), farm yard manure (46.6%), rice-cum-fish culture (10%), IPM (43.3%), pheromone trap (35%), light trap (13.3%),

intercropping (38.3 %), agroforestry (23.3%), AWD (0%), short duration varieties (46.6%), sorjan method (21.6%) and use of local pesticides(35%). Seventeen CSA practices were existed among eighteen practices in the study area. It is found that about 78.3% of respondents were using high yielding varieties as these varieties of crops take less time for maturing and thereby enables the farmers to go for multiple cropping. This technology has become popular among most of the farmer, that they hardly use local varieties. Necessary steps should be taken to conserve the biodiversity of local variety. The farmers of the study area have mostly introduced perching technique in the crops and vegetables field as a climate-smart agricultural practice. It is found that about 63.3% of respondents were involved in this eco-friendly technique in order to cope with adverse effect of climatic change in terms of food security. Farmers in the study area are achieving remarkable success in controlling pest in the paddy field by using this method as an alternative to pesticides. This modern technology has become very popular to the farmers as it has reduced production cost to a great extent and enhanced rice production significantly. Previously, farmers were using toxic insecticides in the fields to control the insects which have far reaching effects on environment and on human health. By using perching method, farmers were producing crops and vegetables free from toxic insecticides with lower production cost and at the same time helping to maintain balance of the environment. As a result, the method was getting immense popular at the study area. Hasan *et al.* (2018) also identified sorjan method, urea deep placement, organic fertilizer, mulching, use of pheromone trap and rain water harvesting as CSA practices in Kalapara upazila in Patuakhali, Bangladesh. It is perceived that existing above mentioned practices have been used to (i) increase agricultural productivity and food security for resilient agriculture, (ii) adapt agriculture to climate change, and (iii) modify agriculture to mitigate climate change as like FAO Climate-Smart Agriculture framework (Lipper *et al.* 2014).

The study area was categorized into six pools. Paudel *et al.* (2017) also reported six pools of CSA options as carbon smart, nutrient smart, water smart, weather smart, knowledge smart and energy smart. But, practices under the energy smart pool were not found. In addition, a new pool as “pest smart” was proposed. As a result, existing seventeen CSA practices of the study area were also divided into six pools. It is noted that few practices were found in more than one

pool e.g., adjusting planting time practice was found in both weather smart and knowledge smart pool.

“Approach for up-scaling” means the sequence of steps used to promote the extension and demonstration of potential CSA technologies in collaboration with local communities and government stakeholders to make informed decisions for climate change adaptation in agriculture. Based on the understanding from the research, a three-tier up-scaling approach was proposed consisting of different time scale for the study area as well as also applicable for other area of Sylhet district. In this up-scaling approach there are information transfer approach, entrepreneur development approach and policy inclusion approach. Proposed “up-scaling approach” would have vital role to address the challenges of climate change and variability in agriculture. Paudel *et al.* (2017) also proposed a three-tier up-scaling model for CSA options in Nepal.

12. Research highlight/findings:

- i) Critical issues and composition of existing agroforestry systems in Sylhet region have been identified.
- ii) Status of climate smart agricultural practices have been documented ;
- iii) Attributes of climate smart agricultural practices have been documented;
- iv) The levels of use of climate-smart practices were not satisfactory in the both study areas.
- v) Level of importance have been observed of CSA practices
- vi) Challenges associated with climate smart agricultural practices have been documented;
- vii) Up-scaling approach of potential climate-smart agricultural practices have been proposed;
- viii)The crops can be grown in the existing agar (*Aquilaria malaccensis*) garden as agroforestry systems without hampering the growth and development of agar plant.
- ix) Tea (*Camellia sinensis*) is the most suitable as associated crops with agar plant followed by ginger (*Zingiber officinale*), pineapple (*Ananas comosus*) and bilati dhonia (*Eryngium foetidum*) which provide the additional year round production from existing agar garden.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Laptop Laser printers UPS (Offline) Scanner DSLR Camera.	55000/- 19800/- 5800/- 5300/- 38500/-	Laptop Laser printers UPS (Offline) Scanner DSLR Camera.	55000/- 19800/- 5800/- 5300/- 38500/-	100 % Achievement
(b) Lab & field equipment	Rain gage Soil Metric Potential Micrologger	123000/- 32000/- 359200/-	Rain gage Soil Metric Potential Micrologger	123000/ - 32000/- 359200/ -	
(c) Other capital items	File Cabinet Front Chair	20000/- 16000/-	File Cabinet Front Chair	20000/- 16000/-	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Automated Agrometeorological Station		1			
Field Laboratory		1			
Project office				1	

3. Training/study tour/ seminar/workshop/conference organized: N/A

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	292600	253152	253152	-	100	-
B. Field research/lab expenses and supplies	665000	680663	680663	-	100	-
C. Operating expenses	335000	327040	327040	-	100	-
D. Vehicle hire and fuel, oil & maintenance	245000	260583	260583	-	100	-
E. Training/workshop/seminar etc.	0	0	0	-		-

F. Publications and printing	115000	0	0	-	0	-
G. Miscellaneous	20150	3000	3000	-	100	-
H. Capital expenses	677250	650315	650315	-	100	-

D. Achievement of Sub-project by objectives:

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
To document the composition & diversity of existing agroforestry practices	Development and pre testing of questionnaires and field survey for documenting existing agroforestry practices	Report and Thesis	Information generation on existing agroforestry practices
To analyze the explanatory factors responsible for the adoption of agroforestry as well as Climate-Smart Agriculture practices	Development of questionnaire for field survey & FGD	Report, Thesis & Journal publication	Status of Climate-Smart Agricultural practices & developed up-scaling approach
To identify environmentally friendly, economically profitable and socially acceptable agroforestry practices in Sylhet region.	Experiment on agar (<i>Aquilaria malaccensis</i>) based agroforestry system	Report and thesis	Development of potential agar (<i>Aquilaria malaccensis</i>) based agroforestry system

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/booklet/leaflet/flyer etc.	Technology bulletin -01; Booklet-01	-	Technology bulletin: Potential agar (<i>Aquilaria malaccensis</i>) based agroforestry practices for year round production. Booklet: Status of Climate-smart agricultural practices in crop production in Sylhet region.
Journal publication	03	1	Afrin R, Talucder M S A, Paul G and Uddin M S. 2017. Status of climate-smart agricultural practices in Jaintapur upazila of sylhet district. Journal of Sylhet Agricultural University 4(2):251-260.
Information development			
Other publications, (MS Thesis)	0	4	MS Thesis*

***Thesis Title:**

- i) Transforming agar (*Aquilaria malaccensis*) garden into agar based agroforestry system for provisioning year round production, MS Thesis, Department of Agroforestry & Environmental Science, Sylhet Agricultural University, Sylhet.
- ii) Climate-smart agricultural practices in crop production at Jaintiapur upazila of Sylhet district, MS Thesis, Department of Agroforestry & Environmental Science, Sylhet Agricultural University, Sylhet.
- iii) Farmers' perception towards climate-smart-agricultural practices in Golapgonj upazila of Sylhet district, MS Thesis, Department of Agroforestry & Environmental Science, Sylhet Agricultural University, Sylhet.
- iv) Farmers' perception towards agroforestry practices in Golapgonj upazila of Sylhet district, MS Thesis, Department of Agroforestry & Environmental Science, Sylhet Agricultural University, Sylhet.

F. Technology/Knowledge generation/Policy Support:

I. Generation of technology (Commodity & Non-commodity)

Not applicable

II. Generation of new knowledge that help in developing more technology in future

New knowledge on status of climate smart agricultural practices with associated challenges and potential agar based agroforestry systems were documented that will help in developing new technologies in future.

III. Technology transferred that help increased agricultural productivity and farmers' income

Not applicable

IV. Policy Support

Results of the current study will help policy maker to undertake appropriate strategies to improve Climate-Smart Agricultural practices and agar based agroforestry farming in Bangladesh.

G. Information regarding Desk and Field Monitoring

● **Desk Monitoring:**

- Annual workshop on CRG sub-project under NRM Division on 18-20 September 2018 in the Auditorium, BARC, Farmgate, Dhaka

- Monitoring workshop on CRG Sub-projects on 15-16 May 2018 in the Auditorium, BARC, Farmgate, Dhaka
- Training Workshop on Implementation Procedure of CRG sub-project - 18 June 2017 in the Training Room, Training Building, BARC, Farmgate, Dhaka
- Research Review Workshop on CRG Sub-projects- on 21 December 2017 at 10:00 am to 4:00 pm at the BARC Auditorium, Farmgate, Dhaka

- **Field Monitoring**

Monitoring team	Time of field visit	No. of visit	Output/Remarks
Director & his team, NRM, BARC	17 February, 2018	01	Field experiment was revised according to suggestions.
Director & his team, PIU, NATP-2, BARC	07 April, 2018	01	Activities got momentum.
Monitoring team, SAURES, SAU, Sylhet	08 January, 2018 03 June, 2018	02	Activities got momentum.
Faculty members	30 June, 2018	01	Activities got momentum.

H. Lesson Learned

- The levels of use of agroforestry practices as well as other climate-smart agricultural practices in crop production are not satisfactory in the study area, which implies the scope for intervention in research and extension.
- Tea (*Camellia sinensis*), zinger (*Zingiber officinale*), pineapple (*Ananas comosus*) and bilati dhonia (*Eryngium foetidum*) Pineapple could be grown without hampering the growth and development of existing agar (*Aquilaria malaccensis*) tree under agar based agroforestry technology.

J. Challenges

- Heavy rainfall during rainy season restricted the crop production activates especially turmeric (*Curcuma longa*), zinger (*Zingiber officinale*) and bilati dhonia (*Eryngium foetidum*).
- Drought during winter season hinders the growth and development of agar (*Aquilaria malaccensis*) plants and its associated crops e.g., pineapple (*Ananas comosus*), zinger (*Zingiber officinale*), turmeric (*Curcuma longa*), bilati donia (*Eryngium foetidum*), multa (*Citrus sinensis*) and tea (*Camellia sinensis*), as well as.
- Lack of irrigation facilities and labour, fruit damage by squirrel and others animals, damage of agar (*Aquilaria malaccensis*) stand due to pest attack, scattered cultivation by small holders, lack of long term investments for improving this promising combined production systems are some of the added perils.

Signature of the Principal Investigator

Date

Seal

Counter signature of the Head of the organization/authorized representative

Date

Seal

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APPENDIX I

AN ENGLISH VERSION OF THE INTERVIEW SCHEDULE

Developed by

Climate-Smart Agriculture Lab.

Department of Agroforestry and Environmental Science

Sylhet Agricultural University, Sylhet 3100

An Interview Schedule for a Research Study 1

An Interview Schedule for a Research Study 1

STATUS OF AGROFORESTRY PRACTICES IN JAINTIAPUR AND GOLAPGONJ UPAZILA OF SYLHET DISTRICT

Sl. No. , Date :

Village: , Union: , Upazilla:

1. Name of respondent:

2. Age: Years

3. Educational status (0-16):

4. Family size (Total number):

5. Farm size (in local unit):

6. Annual family income:

7. Credit received (Received-1, Not received-0)

8. Remittance (Received-1, Not received-0)

9. Training (Received-1, not received 0):

10. Involvement in a society/organization (Not involved-0, Member-1, President/Secretary-2):

11. Land topography (Plain-1, Slope-2, Both-3):

12. Erosion hazards (Found-1, Not found-2):

13. Distance to local market (Km):

14. Distance to road (Km):

15. Involvement in production activities:

Involvement of activities	Yes	No
Rice cultivation		
Vegetable cultivation		
Crop land agroforestry production		
Homestead agroforestry production		
Roadside bean cultivation		
Pineapple cultivation		
Komlalebu cultivation		
Malta cultivation		
Satkora cultivation		
Jara lebu cultivation		
Taikor cultivation		
Lebu cultivation		
Gol morich (black pepper) cultivation		
Betel leaf (Pan) cultivation		
Supari cultivation		
Drumstick (Sajna) cultivation		
Agarwood cultivation		
Naga morish cultivation		
Apiculture (Bee keeping)		
Medicinal plant cultivation		
Sitol pati/ Murta cultivation		
Bet cultivation		
Grass or any fodder production		
Livestock (Cattle/Pasture/Poultry/Turkey/Titir)		
Other (if any):		

16. Where did you get seed/vegetative material of crops?

Seed aid/Local market/family production/ Government nursery/Private nursery/other (specify)

17. List of major management practices of crops (e.g., Weeding, thinning, gap-filling, mulching, irrigation, manure & fertilizer application etc.):

18. List of plant species in the homestead area:

19. List of medicinal plants with their uses:

20. List of Vegetables & Spices:
21. List of newly planted species:
22. List of existing agroforestry practices:
23. List of different agroforestry combinations:
24. Agroforestry benefits & disadvantages:

Statements	Degree of agreement				
	Strongly agree	Agree	Not sure	Not agree	Not agree at all
BENEFITS					
Increased production					
Improve microclimate					
Reduce chemical fertilizer					
Reduce crop loss					
Reduce weed infestation					
DISADVANTAGES					
Increased competition					
Problems in management					
Pruning material harms crop					

25. Please rate the following statements on how they have positively contributed towards livelihood improvement:

Statements	Degree of agreement				
	Strongly agree	Agree	Not sure	Not agree	Not agree at all
Health & nutritional improvement					
Life style improvement					
Interrelation between producer & customer					
Value addition					
Marketing development					
Germplasm introduction					

Thank you very much for your good cooperation

Signature of the interviewer

APPENDIX II

AN ENGLISH VERSION OF THE INTERVIEW SCHEDULE

Developed by

Climate-Smart Agriculture Lab.

Department of Agroforestry and Environmental Science

Sylhet Agricultural University, Sylhet 3100

An Interview Schedule for a Research Study 2

STATUS OF CLIMATE-SMART AGRICULTURAL PRACTICES IN JAINTIAPUR AND GOLAPGANJ UPAZILA OF SYLHET DISTRICT

Sl. No.

Date:

Village: Union: Upazilla:
.....

1. Name of respondent:

2. Age: Years

3. Educational status:

No education (0)/ Primary (1-5)/ Secondary (6-10) / Higher Secondary (10-12) /
University level (>12).

4. Family size (Total number):

5. Farm size (acre):

6. Annual family income (In Taka):

7. Credit received (Received-1, not received-0)

8. Remittance (Received-1, not received-0)

9. Agricultural Training (Received-1, Not received 0):

10. Extension contact (Number of visit per year):
11. Involvement in a society/organization (Involved-1, Not involved-0):
12. Land topography (Plain-1, Slope-2, Both-3):
13. Erosion hazards (Found-1, not found-0):
14. Distance from home to local market (Km):
15. Distance from home to road (Km):
16. Do you have access to weather forecast services (e.g. floods, droughts, late rains)?
Yes/ No
17. Do you have access to meteorological information sufficient for your farm system?
Yes/ No
18. How important is meteorological information to manage your farm system?

Very important/ Medium important/less important /Not important

19. Water availability in the study area:

Domestic	Increase	/	decrease
Irrigation	Increase	/	decrease

20. Sources of water for major uses:

Category	Water sources
Domestic	
Irrigation	

21. What kind of climate changes have you noticed?

Sl.No.	Climatic variables	Increased	Decrease	No change	Don't know
1.	Lightening				
2.	Rainfall				
3.	Temperature				
4.	Drought				
5.	Flash Flood				
6.	Hailstorm				
7.	Unpredictable rainfall				
8.	Earthquake				
9.	Fog				
10.	Cloudy sky				

11.	Speedy Wind				
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22. What kind of climate change effect have you noticed?

Sl. No.	Types of Impact	Increased	Decrease	No change	Don't know
1.	Crop failure				
2.	Cost of crop production				
3.	Pest (Insect & Disease) attack				
4.	Soil fertility				
5.	Other (if any)				

23. Existing Climate-Smart Agricultural practices used by the respondents:

CSA Practices	Extent of adoption			
	High (3)	Medium (2)	Low (1)	Not at all (0)
High yielding crop varieties				
Improved livestock breed				
Adjusting planting time				
Crop rotation				
Muching				
Application of Vermicompost (Zir)				
Farm Yard Manure application				
Rice-cum-fish farming				
IPM				
Pheromon Trap				
Light trap				
Perching in paddy field				
Intercropping (mixture of crop)				
Agroforestry (Crop under tree)				
Alternate Wetting & Drying (AWD)				
Short duration varieties				
Sorjan method				
Use of local pesticide				

24. Respondents' perception towards potential Climate-Smart Agricultural practices:

CSA Practices	Respondent's perception			
	Very important (3)	Moderate important (2)	Less important (1)	No opinion (0)
Reduced or Zero tillage				
Integrated Nutrient Management (INM)				
Solar based irrigation				

Water Harvesting (Bund, contour ridging, earth bund, planting pits, Dam)				
Producion & application of Biochar				
Floating bed fodder cultivation				
Floating seed bed				
Sand bar cropping				
Pit planting				
Mounds				
Terrace				
Strip cropping				

25. Constraints in using Climate-Smart Agricultural practices:

Constraints	Extent of constraints			
	Very constraints (3)	Moderate constraints (2)	Low constraints (1)	No opinion(0)
Lack of improved variety				
Lack of improved livestock bred				
Lack of necessary technical knowledge				
Lack of advice in proper time				
Lack of training				
Lack of incentive				
Lack of capital				
Lack of irrigation water				
Unavailability of farm inputs				

Thank you very much for your good cooperation

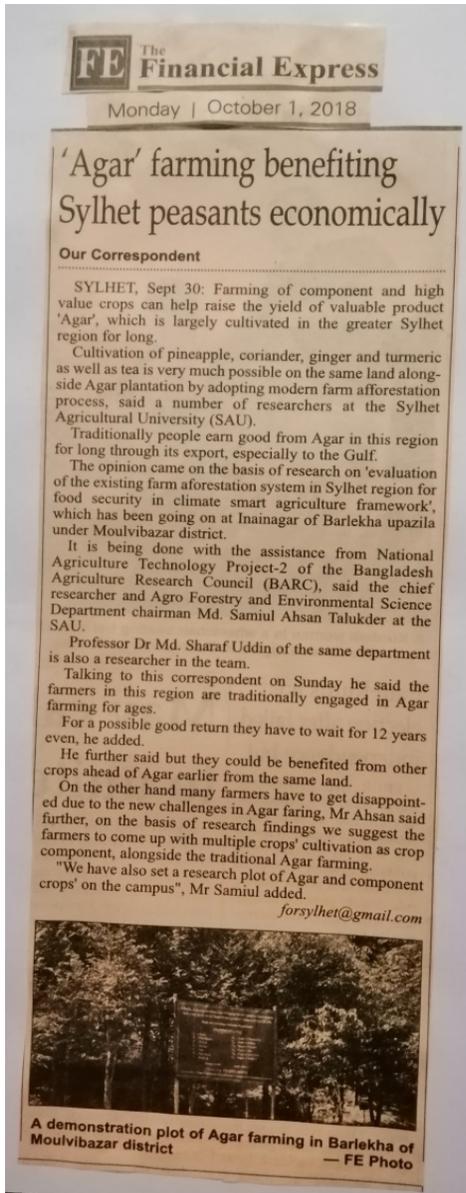
Signature of the interviewer

Signature or finger-prints of the farmer

APPENDIX III

Media Coverage

Media Coverage on research findings		
Name & Type of Media	Date of Coverage	Remarks
National Newspaper (English)	01.10.18	01
National Newspaper (Bangla)	24.9.18; 25.9.18	02
Local Newspaper	23.9.18; 24.9.18	07
Online News portal	22.9.18; 23.9.18; 29.9.18	08



Media Coverage on establishing Automated Agro-meteorological Station		
Name & Type of Media	Date of Coverage	Remarks
National Newspaper (English)	18 & 19 October'18	03
National Newspaper (Bangla)	18, 19 & 21 October'18	05
Local News paper	18 October'18	07
Online News portal	17 & 18 October'18	08



News published in Daily Prothom Alo on 18 October, 2018



News published in The Financial Express on 19 October, 2018

কৃষি আবহাওয়া স্টেশন

চাষাবাদে নতুন আশা

একটি এলাকার বায়ুমণ্ডলের তাপমাত্রা, বৃষ্টিপাত, মৃত্তিকার তাপমাত্রা ও তড়িৎ পরিবাহিতা, মেঘের গতিবিধি—এসব বিষয় যদি দীর্ঘদিন পর্যবেক্ষণ করা হয় এবং প্রতিদিন এ-সংক্রান্ত তথ্য কম্পিউটারের ধারকযন্ত্রে সংরক্ষণ করা হয়, তাহলে সবচেয়ে বেশি উপকৃত হতে পারেন কৃষক। দীর্ঘদিন ধরে এসব তথ্য জমা করে বানানো উপাত্ত ভান্ডার বিশ্লেষণ করে কৃষক কোন সময়ে কোন জমিতে কোন ফসল আবাদ করবেন, সে বিষয়ে বিজ্ঞানভিত্তিক সিদ্ধান্ত দেওয়া সহজ হয়। এই সিদ্ধান্ত অনুসরণ করে চাষাবাদ করলে আশা করা যায়, কোনো আকস্মিক দুর্ঘটনা না হলে ফসলের সর্বোচ্চ ফলন হবে।

উন্নত দেশগুলোতে এই ব্যবস্থা বহু আগে থেকেই আছে। আনন্দের খবর হলো, আমাদের সিলেট কৃষি বিশ্ববিদ্যালয়ে গত বুধবার এই ব্যবস্থা চালু হয়েছে। এটি একটি স্বয়ংক্রিয় কৃষি আবহাওয়া স্টেশন। এই স্টেশন থেকে সিলেট অঞ্চলের কৃষি আবহাওয়া সম্পর্কিত বিভিন্ন তথ্য জানা যাবে। এর তত্ত্বাবধানে থাকছে বিশ্ববিদ্যালয়ের কৃষি বনায়ন ও পরিবেশবিজ্ঞান বিভাগের ক্লাইমেট স্মার্ট অ্যাগ্রিকালচার ল্যাব। বিভাগের নার্সারিতে স্থাপিত এই স্টেশন নির্মাণে অর্থায়ন করেছে বিশ্বব্যাংক, ইউএসএআইডি ও বাংলাদেশ সরকার।

স্টেশনটি উচ্চক্ষমতাসম্পন্ন তথ্য প্রক্রিয়াকরণের সাথে সংযুক্ত করা হয়েছে। এতে প্রতিনিয়ত নিরবচ্ছিন্নভাবে বায়ুর তাপমাত্রা, বৃষ্টিপাত, মৃত্তিকার তাপমাত্রা ও মৃত্তিকার তড়িৎ পরিবাহিতা ইত্যাদি তথ্য সংরক্ষণ হতে থাকবে। প্রয়োজন অনুযায়ী কম্পিউটারের সাহায্যে ওই ধারকযন্ত্রে সংরক্ষিত তথ্য কাজে লাগানো যাবে। স্টেশন থেকে দীর্ঘ মেয়াদে কৃষি আবহাওয়ার মৌলিক তথ্যগুলোর একটি সংগ্রহশালা সৃষ্টি হবে। এটা জলবায়ু পরিবর্তনসংক্রান্ত কৃষি গবেষণার ক্ষেত্রে বিশেষ সহায়ক ভূমিকা রাখবে। শিক্ষার্থীরা এখান থেকে হাতে-কলমে কৃষি আবহাওয়ার মৌলিক নিয়ামকগুলো পরিমাপের সর্বাধুনিক যন্ত্রপাতি ও সংশ্লিষ্ট প্রোগ্রামিং প্যাকেজ সম্পর্কে অত্যন্ত প্রয়োজনীয় প্রায়োগিক জ্ঞান ও দক্ষতা অর্জন করতে পারবেন। এই অবস্থা যত বেশি বিকশিত হবে, প্রকৃতির কাছে জিম্মি হয়ে থাকা অবস্থা থেকে আমরা তত বেশি বের হয়ে আসার সুযোগ পাব।

সম্প্রতি নেপালের কাঠমান্ডুতে অনুষ্ঠিত জলবায়ু পরিবর্তন ও কৃষির সম্পর্কবিষয়ক একটি সম্মেলনে ২৫টি দেশের শতাধিক বিজ্ঞানী-গবেষকও এই ধরনের বিষয় নিয়ে আলোচনা করেছেন। বাংলাদেশি বিজ্ঞানীদের একটি দলও সেখানে অংশ নিয়েছিল। সেখানে বিজ্ঞানীরা মেঘের গতিবিধি পর্যবেক্ষণ করে কৃষিব্যবস্থাকে সাজানোর কথা বলেছেন।

আমাদের দেশে কৃষকদের কথা মাথায় রেখে চাষাবাদবান্ধব পূর্বাভাস দেওয়া হচ্ছে না। সিলেটে স্থাপিত কৃষি আবহাওয়া স্টেশন ওই বিভাগের চাষীদের সামনে সেই পথ খুলে দিয়েছে। এই সুবিধা এখন সারা দেশে ছড়িয়ে দেওয়ার কাজ করতে হবে। তাহলেই এ দেশে আরেকটি কৃষিবিপ্লব সম্ভব হবে।

Editorial published in Daily Prothom Alo on 21 October, 2018

APPENDIX IV

Pictorial view of permanent establishment from this Project (ID-439)



Automated Agrometeorological Station



Agroforestry Field Laboratory



Renovated and decorated Laboratory with Thai partition and screen



Biography of Principal Investigator



Mohammad Samiul Ahsan Talucder is specialized in climate-smart agriculture, food security, poverty reduction, agroforestry, neglected & underutilized species, non-timber forest product, greenhouse gases, agricultural & forest meteorology toward sustainable agricultural and forest services. He is pursuing climate-smart agriculture which aims for triple wins in production increase, reduction of greenhouse gas emission and resilience capacity building. In his PhD research, he has conducted an experiment on the exchange of water, carbon and energy in a rice ecosystem in South Korea. He has trained in theory and application of the state-of-the-art eddy covariance technique combined with laser technology. It is essential for both developed and developing countries to successfully adapt to and manage climate change. He is a potential next generation leader for fulfilling the challenge of sustainable ecological-societal systems through education and research in academia in Bangladesh. He has published fifteen research articles in different national and international journals and attended at least ten conferences at home and abroad. Recently, He has established Climate-Smart Agriculture Lab. There are two field laboratories, one modern 'Automated Agrometeorological Station', Prototype Biochar *Klin* and several demonstration plots in farmers' field under his lab. Several MS students are pursuing in the area of climate-smart agriculture in this lab under his supervision. Meanwhile, eleven MS students graduated under his supervision. Most of those MS Thesis are Climate-Smart Agriculture related e.g., "Status of climate-smart practices in boro rice cultivation in Sylhet sadar upazila"; "Climate-smart agricultural practices in crop production in Jaintiapur upazila of Sylhet district"; "Status of agroforestry practices in Golapganj upazila of Sylhet district"; "Transformation of agar (*Aquilaria malaccensis*) garden into agar based agroforestry system for provisioning year round production"; "Farmers' perception towards climate-smart-agricultural practices for resilient agriculture in Golapgonj upazila of Sylhet district"; "Livelihood status of urban slum people in Sylhet City: A bottleneck for sustainable city"; "Status of homestead-based black pepper (*Piper nigrum*) gardening in north-eastern Bangladesh: A promising climate-smart solution for rural livelihood improvement". As Principal Investigator (PI), he has experience of handling several national and international funded research projects such as "Evaluation of tree-crop interaction from existing agroforestry systems in Sylhet region for food security by the lens of climate-smart agriculture framework" funded by World Bank, USAID, IFAD & GoB; "Methane and nitrous oxide emission status and mitigation options from rice paddy in Sylhet region" funded by Ministry of Science and Technology, Government of the People's Republic of Bangladesh (GoB); "Collection and evaluation of black pepper (*Piper nigrum*) germplasm under agroforestry system in Sylhet region" funded by University Grants Commission of Bangladesh (UGC). Currently, two reserach projects are on-going as PI : (i) "Evaluation of vegetative propagation methods of black pepper (*Piper nigrum*) germplasm under different rooting media" funded by Sylhet Agricultural University Research System (SAURES) and University Grants Commission (UGC) of Bangladesh for 2019-2020; (ii) "Up-scaling of black pepper (*Piper nigrum*) based homestead agroforestry for poverty reduction of rural people in Sylhet region" funded by BANBIES, Ministry of Education, Government of the People's Republic of Bangladesh for 2019-2022. He is also one of the five pioneer members of "Interdisciplinary Research for Future Agriculture" group. He is married with Dr. Nahid Arjuman Banu and blessed with a son Ahnaf Ahsan and a daughter Arwa Ahsan.