CROP DECISION MAKING MODEL AND IMPACTS OF CROP SELECTION ON THE LIVELIHOOD OF FARMERS IN COASTAL AREA

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by

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The thesis titled **'Crop Decision Making Model and Impacts of Crop Selection on the Livelihood of Farmers in Coastal Area'** submitted by Taznin Naher, Roll No: 0413282015F, Session: April 2013, has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Science in Water Resources Development on September 3, 2016

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It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

....

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Dedicated to

My Respected Parents

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Abstract

This study was carried out to understand the farmers' decision process regarding the selection of Rabi crops in a coastal area, to find out their water management practices and the impacts of selected crop on the livelihood of the farmers. The study was conducted during the Rabi season of 2013-14 in two polders, namely Polder 31 and Polder 32 at Dacope Upazila of Khulna district. The farmers' decision model was developed on the basis of individual interview (II) with farmers'. The individual interview was also conducted to collect information on number, amount and timing of irrigation, yield, and input use for the selected crops (Boro rice, sunflower and sesame). Focus group discussion (FGD) was conducted on the selected farmers to develop farmers livelihood security index (FLSI) based on selected indicators of five livelihood assets (Social, Human, Natural, Financial and Physical).

From the farmer's decision model, it was found that the important parameters affecting cropping decision are presence of soil salinity in top soil, lack of fresh surface water for irrigation, lack of residual moisture and lack of capital for the production of crops. If the farmers find that the level of soil salinity is below 12 dS/m, have access to canal irrigation water with the level of water salinity below 11 dS/m with storage of about ten irrigations, have access to cost for the production of Boro rice, then they decide to grow Boro rice. When the farmers have access to on-farm reservoirs (OFR)/pond with storage of about two or three irrigations and have the capital for the production of sunflower, then they decide to grow sunflower. When the farmers do not have any source of irrigation water, but have the capital, then they decide to grow sesame with residual moisture content. Otherwise, the land is kept fallow.

From the water management practiced by the farmers and EC of soil analysis, it was found that the average seasonal amount of irrigation water of Boro rice and sunflower was 1000 mm and 220 mm respectively. On the other hand, the calculated seasonal irrigation water requirements (IWR) for Boro rice and sunflower were 1336 mm and 308 mm respectively. The farmers followed AWD method for Boro rice and used hose pipe for sunflower to apply irrigation water. The average residual moisture content was 10% by weight in top soil of sesame. For Boro rice, the average EC (dS/m) of soil at vegetative stage, reproductive and ripening stages were 3.56dS/m, 7.05 dS/m and 6.49dS/m in Polder 31 and 3.73 dS/m, 6.38 dS/m and 8.30 dS/m in Polder 32 respectively. For sunflower, the average EC (dS/m) of soil at vegetative, flowering and heading stage was 2.49 dS/m, 4.65 dS/m and 6.82 dS/m respectively.

From the yield, profitability and livelihood analysis, it was found that the yields of HYV rice, sunflower (Hysun-33) and sesame (local) under farmers' practice varied from 3.00 to 5.90 t/ha, 0.60 to 1.7 t/ha and 0.60 to 0.80 t/ha respectively. The BCR of growing rice varied from 1.53 to 2 whereas for sunflower (Hysun33) and sesame (local) were 1.56 and 1.30 respectively. Different levels of livelihood security were found for Boro rice, sunflower and sesame producing farmers. The highest livelihood security level was found for Boro rice farmer as 83% in polder 31 whereas the lowest security level was measured for sesame farmer as 32% in polder 32. The crop decision model result has ultimately shown that the levels of security for farmers' livelihood were higher in Polder 31 than that of Polder 32.

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List of Abbreviations

AWD	Alternate Wetting and Drying
BBS	Bangladesh Bureau of Statistics
BADC	Bangladesh Agricultural Development Corporation
BARI	Bangladesh Agricultural Research Institute
BCR	Benefit- Cost Ratio
BINA	Bangladesh Institute of Nuclear Agriculture
BMD	Bangladesh Meteorological Department
BRAC	Bangladesh Rural Advancement Committee
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CPE	Cumulative Pan Evaporation
CWR	Crop Water Requirement
DFID	Department for International Development
DAE	Department of Agriculture Extension
EC	Electrical Conductivity
E_F	Field Application Efficiency
ER	Effective Rainfall
ET_c	Crop Evapotranspiration
ET_o	Reference Evapotranspiration
FAP 4	Flood Action Plan 4
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FIR	Field Irrigation Requirement
FLS	Farmers Livelihood Security
FLSI	Farmers Livelihood Security Index
Fsvi	Standardized value of financial asset sub-index
ha	Hectare
Hsvi	Standardized value of Human asset sub-index
HYV	High Yielding Variety

IDRC	International Development Research Centre
IWFM	Institute of Water and Flood Management
IWR	Irrigation Water Requirement
K_c	Crop Coefficient
LLP	Low Lift Pump
LP	Land Preparation
MPO	Master Plan Organization
MP	Murate of Potash
Nsvi	Standardized value of natural asset sub-index
mm	Millimeter
OFR	On Farm Reservoir
Psvi	Standardized value of physical asset sub-index
RRI	River Research Institute
SAWA	South Asian Water
Ssvi	Standardized value of social asset sub-index
SRDI	Soil Resource Development Institute
S&P	Seepage and Percolation
t/ha	Ton per Hectare
TSP	Triple Super Phosphate
Wi	Weighting

Chapter One

Introduction

1.1 Introduction and Background of the Study

The coastal area covers about 32% of the total area of Bangladesh. But, out of the country's total irrigated area of 5.4 m ha of which only about 15.1% is in the coastal area. Out of this area, about 47.6% is irrigated by groundwater and 52.4% by surface water (BADC, 2013). Apart from tidal and storm surges, salinity and scarcity of fresh water for irrigation are the general problems during Rabi season in the coastal areas. Soil salinity is the most dominant limiting factor in the region, especially during the dry season. It affects certain crops at different levels of soil salinity and at critical stages of growth, which reduces yield and in severe cases, total yield is lost. A substantial area of land is tidally affected by saline water. Scarcity of quality irrigation water during dry season limits cultivation of Boro rice and Rabi (winter) crops, and Aus cultivation during kharif-1 (March-July) season. So, the farmers cannot grow irrigated crops largely due to soil salinity and lack of fresh water. In spite of these problems, some farmers grow Boro rice and others grow Rabi crops like sesame, sunflower, watermelon, maize, chili, mungbean etc. and some keep their land fallow. In a study in the upper southwest Bangladesh (non-saline and non-water scarce area), it was observed that the farmers' decision on growing Rabi crops depended on the harvesting time of T. Aman, residual soil moisture, location of land, good Aman harvest, access to capital and irrigation (Miah, 2008).

Rice is the major crop grown in the coastal region. The minor crops grown in the coastal region are vegetable, grass pea, sunflower, maize, potato, green gram, sweet potato, and chili. In coastal area, sunflower is the newly introduced crop during Rabi season for overcoming the salinity effect. As there are limited scopes to grow crops in the winter season because of shortage of fresh water, they want to produce more crops to make the farming a profitable enterprise by developing a facility of sweet water in dry periods (BIOFORSK-BRRI-CEGIS, 2012).

After the crop selection, the farmers' adopt different water management practices to cultivate their crops. The farmer uses canal water (non-saline) and rainwater to cultivate the Rabi crops in coastal areas. The existing canal, on farm reservoir (OFR) and pond are the sources of irrigation water in the coastal area. The farmers conserve non-saline river water in polder canals for irrigation. Then the farmers apply irrigation water by the LLP in Boro rice field during dry periods. Some farmers do not have this facility. They cultivate sunflower and apply OFR and pond water for irrigation. At the beginning of Rabi season, the pond remains filled up 80% with water. The farmers can apply three irrigations with 80% water. They cultivate vegetables, mustard, and sunflower (except rice) with this pond water (BRRI, 2015).

The cropping decisions affect the farmers' livelihoods in the coastal area. There are relationships between the cropping decisions, water management practice, yield and income. The farmers' livelihoods depend on the yield of Boro rice, and Rabi crops (sunflower and sesame etc.). The farmers have less ability to diversify their livelihood activities in coastal areas. Because they have to regularly maintain their crops and livestock, they do not easily accept daily wage employment. Even if such works were flexible and available nearby, social reasons, sometimes make it difficult for these households work for others (Mutahara, 2009).

The livelihood system may be defined as a process of income for living. So there is a close contact between income and livelihood. Livelihood security has a direct relation to the income security (Mutahara, 2009). The net return is a useful tool to evaluate the business, profitability or financial solvency of any kind of agribusiness (Kana et al., 2011).

Livelihood security is an integrating concept where a livelihood comprises of the capabilities, assets (including both all material and social resources) and activities required for a means of living (Scoones, 1998). A livelihood is sustainable when it can cope with and recover from the stress and shocks, maintain its capability and assets, and provide sustainable livelihood opportunities for the next generation (Chambers and Conway 1992). Livelihoods are secured when households have secure ownership of, or access to resources and income earning activities, including reserves and assets, to offset risks, ease shocks and meet contingencies (Chambers, 1989).

1.2 Objectives of the Study

The general objective of the study was to understand about the cropping practices through farmers' decision, water management practices of Boro rice, Rabi crops and the farmers' livelihood security in coastal areas. The specific objectives of the study are:

- To develop farmers' decision making model for crop selection in a coastal area.
- To understand how the water management practices of selected crops affect the yield.
- To find out the impacts of crop selection and yield on the livelihood of the farmers.

The study findings would present a clear idea about the selection criteria and irrigation management practices of selected crops by the farmers' and at the same time, the relation between farmers' livelihood and crop selection in a water scarce (both in terms of quality and quantity) environment.

1.3 Limitations of the Study

The limitations of the study are as follows:

- This study has been conducted in only two polders in one coastal district, which is inadequate to portray the overall scenario of coastal farmers.
- In some cases, the study has suffered from lack of adequate information from the people living in a remote coastal area.

Chapter Two

Literature Review

This chapter is directed to an overview of the farmers' decision making for crop selection in the coastal area of Bangladesh with special concern to the soil and water salinity, irrigation water use and management of selected Rabi crops, livelihood of the farmers and profitability of Boro rice, sesame and sunflower. In Bangladesh some works have been done in these aspects. An attempt is made here to review the most relevant studies.

2.1 Farmers Decision Making Model

Several studies have been carried out in the past in a number of countries on farmers' decision making model.

In the field of agricultural decision making, Gladwin (1980) has developed a "decision tree" descriptive model of cropping decision making that "incorporate some of the simplifying procedures people use in making every day real-life decisions". Gladwin (1983) tested her decision tree model using data gathered from 118 farmers in six sub-regions of the "Altiplano" in Guatemala and obtained a success rate of 90 percent prediction.

Buttel et al. (1990) recognized the importance of socio-informational networks in farmer decision making process. In their study of decision making model, the farmers' decisions were affected by neighboring farmers' opinions and advices, as well as by institutionalized sources such as extension and mass media.

Intal et al. (1990) indicated that the cropping decision tree model is applicable to the choice of a major diversified crop involving a free choice situation. The model appears promising as a diagnostic guide that can be used by change agents in determining whether or not farmers are ready to crop diversity.

Lampayan et al. (1994) developed a descriptive model to understand how farmers make decisions in the real world and the steps they go through in the process. The model was a cognitive model of farmer's rice crop establishment decision in rain fed lowlands.

Merot et al. (2008) developed a conceptual model of the decision making process that determines the irrigation management of a cropping system, on which a simulation model is to be based. Interviews focused on water management were carried out, to understand how farmers manage their irrigation and how their decisions determine the technical system applied on the farm. These interviews were then analyzed using the ‘‘model for action” concept, to generate a conceptual model of the decision system, which is organized as a sequence of decision rules describing irrigation management. This model contains five elements: (1) spatial and temporal factors relevant to decision-making in terms of irrigation and hay cropping; (2) no interaction between the grassland cropping system and the sheep rearing system; (3) five rules to describe irrigation management in the cropping system; (4) major water distribution constraints; and (5) two interrelated operations, hay mowing and irrigation. The rules for irrigation decision-making are written as: ‘‘If <Indicator><Operator><Threshold> Then <Action1> Else <Action2>”. This conceptual model was used as the basis of a decision support system that includes models of grass growth and hydrology.

Ayubu et al. (2013) studied to investigate decision support systems for assisting strategic and tactical decision making of smallholder farmers to reduce climate risks and increase crop productivity of semi-arid areas. Specifically, the study assessed farm-level decisions used by the farmers for reducing climate risks; examined information, communication and knowledge sharing strategies for enhancing decision making and designed a system for assisting the farmers in selecting appropriate options for improving crop productivity. Development of DSS was governed by design science where prototyping approach was used to allow complete participation of end-users. The proposed architecture allows different agricultural actors participate in communicating agricultural information and sharing of knowledge with smallholder farmers. The DSS was implemented and assessed by farmers as a useful tool for accessing information and advisories in agricultural systems. The mobile phones used by farmers to access the wealth of agricultural knowledge and policies from research centers and government resources.

Dury et al. (2013) surveyed 30 farmers to study the dynamics of their cropping-plan decision making on irrigated arable farms. Using methods from cognitive science, they analyzed the ways farmers managed uncertainty through planning and reactive decisions. In this study, they showed that representing cropping-plan selection only as a resource-allocation or crop-rotation-design problem is not sufficient to account for farmers' decision-making processes. They showed that cropping-plan decision-making does not occur once per year or per rotation, as is usually represented in models, but is a continuous process mixing design and adaptive activities. They described the concepts that farmers use to plan cropping over time. They also highlight the importance of organizing farmland into spatial crop-management blocks as a major determinant of cropping-plan strategies. They argued that deep understanding of these processes at the farm level is required before it is possible to model and design flexible and environmentally friendly cropping systems that fit with farmers' reality.

In Bangladesh, a few studies have been carried out in the past in the development of farmers' decision making model.

Saleh et al. (2002) developed a decision model on whether to grow a Rabi crop or to keep the land fallow. The study was conducted in three villages of the Magura district of West Bangladesh during the dry seasons of 1997-98 and 1998-99 on fifty randomly selected farmers from each of the three villages, connected by a village road. A two stage descriptive model on decision to grow a Rabi crop and selection of the Rabi crop was then developed based on the information collected from the questionnaire and discussion with the farmers. The decision to grow a Rabi crop is very much dictated by the harvest time of the preceding Aman (monsoon rice) crop. If the Aman crop is harvested by 15 December, then irrespective of the soil moisture condition, farmers go for a Rabi crop. If Aman rice is harvested beyond 15 December, then there is very little moisture left in the soil for adequate germination and only production of chick pea, which is considered to be drought resistant, is possible. The five factors harvesting time, soil moisture, tilling equipment, neighbor effect and resources control the decision process to grow a Rabi crop after monsoon rice.

Miah, (2008) studied to understand the farmers' decision process regarding selection of non-rice crops. The study was conducted during the Rabi season in 2008-09 at Shibchar Upazila of Madaripur district. Two descriptive models; one of the decision to grow a Rabi crop and the other on what Rabi crop would be grown, were developed on the basis of a questionnaire survey and discussions with the farmers. From the farmer's decision model, it was found that some farmers do not cultivate Aman rice because they want to start early in the Rabi season and grow onion/garlic or HYV wheat. Basically, they are the owner of high land and they believe that early Rabi crops are more profitable than the Aman rice. If the preceding Aman crop is harvested within November then the farmers with no access to capital and irrigation grow a mixed crop of mustard and lentil. On the other hand, farmers who have access to capital and irrigation, grow a mixed crop of onion and garlic.

2.2 Irrigation Water Management on the Yield of Boro-rice in Saline Areas

The literature is not found in other countries the effect of irrigation water management on yield of BRRI Dhan-47, BINA Dhan-8 and BRAC-5 (Shakti-2) Boro rice varieties in the coastal area. Some studies have been carried out on the effect of irrigation water management on the yield of BRRI Dhan-47, BINA Dhan-8 and BRAC-5 (Shakti-2) in the saline areas of Bangladesh.

Barua et al. (2015) conducted a study on BRRI Dhan-47 based on grain yield, growth duration, salt tolerance and farmers' opinion. The yield of BRRI Dhan-47 was 5.81 t/ha.

Bangladesh Rice Research Institute (BRRI) has released more than 65 modern varieties for the different seasons of the year. Salt tolerant varieties include BRRI Dhan-47 which can tolerate 6-8 dS/m of salinity in the Boro season (BARC, 2014).

Bangladesh Institute of Nuclear Agriculture (BINA) has released Binadhan-8 and Binadhan-10 as a salt tolerant high yielding rice varieties. BINA Dhan-8 is released in 2010. It is semi dwarf, early maturing and medium bold grain rice variety. It requires 130-135 days to mature. It is moderately resistant to bacterial leaf blight, sheath blight, brown plant hopper and stem borer. Under salt stress, maximum grain yield is 5.5 t/ha (average 4.5-5.5 t/ha) and in non-saline area, maximum 9.0 t/ha and average 7.5-8.5 t/ha. This variety is most suitable in saline areas of Bangladesh and also other, non-saline areas (BARC, 2014).

Binadhan-10 is a salt tolerant variety for the Boro season, which can tolerate up to 12 dS/m of salinity, released in 2012. The variety is capable to produce a higher seed yield (5-6 t/ha under salt stress). Binadhan-10 is early maturing (127-132 days) than other salt tolerant varieties. The variety possesses deep green and erect flag leaves, trunks and stems are strong, sturdy and remain erect (no loading) even in stormy weather and no shattering. Disease incidence and pest attacks are very low. In non-saline condition, potential yield is 8.5 t/ha (average 7.5 t/ha). Grain is medium long, slender and bright color. The variety is suitable for both Aman and Boro seasons (BARC, 2014).

Biswas et al. (2009) conducted experiments on yield performance of BRRI Dhan-47 in the saline ecosystem of Khulna district. They selected both Terokhada Upazilla and Dacope Upazilla. In Terokhada Upazilla where salinity was very low underground water was used for irrigation. The yield of BRRI Dhan-47 was 6.3 t/ha. In Dacope, water preserved in canals/ponds (fresh /very low saline water from rain or river sources) was used for irrigation. In the Kailashgonj union of Dacope, BRRI Dhan-47 yielded 6.6 t/ha. In the Pankhali union of Dacope, BRRI Dhan-47 yielded 3.0t/ha because BRRI Dhan-47 suffered from high salinity at the reproductive stage and water scarcity.

Huq and Rabbani, (2011) conducted a study on BRRI Dhan-47. The average yield of BRRI Dhan-47 was 6.0 t/ha. Islam et al. (2013) conducted an experiment on the yield of Boro rice (BRRI Dhan-28) under different water management practices. There were two irrigation levels, one is alternate wetting and drying, another is continuous flooding. The highest yield was 5.9 t/ha at alternate wetting and drying (AWD) and the low yield was 4.04 t/ha at continuous flooding.

Rahman et al. (2014) carried out a field experiment on the effect of alternate wetting and drying (AWD) irrigation for Boro rice cultivation in Bangladesh. The yield was 4.7 t/ha at continuous standing water, 5.7 t/ha at Irrigation when water is 15cm below from the soil surface, 5.5 t/ha at Irrigation when water is 20cm below from the soil surface, 5.3 t/ha at Irrigation when water is 25 cm below from the soil surface.

Rashid et al. (2014) conducted a comparative study between BRRI Dhan-47 and BINAdhan-8. The field soil salinity of BRRI Dhan-47 was 4.30 dS/m, 4.66 dS/m, 4.88 dS/m, 5.34 dS/m and 6.35dS/m; on the other hand the field soil salinity of BINAdhan-8 was 4.30 dS/m, 4.65 dS/m, 4.86 dS/m, 5.39 dS/m and 6.17 dS/m.

2.3 Irrigation Water Management on the Yield of Sunflower in Saline Areas

Some studies have been carried out in the past in some of the countries the effect of irrigation water management on the yield of sunflower.

El-Kader et al. (2006) determined the effects of soil quality on yield of sunflower grown under increasing levels of soil salinity. The experiment revealed that salinity reduced crop yield on average by 20% depends upon the salinity level and composition of salts.

Rauf et al. (2012) conducted an experiment on yield of sunflower as influenced by reducing irrigation condition. In the experiment, the yield was 3.04 t/ha at full irrigation, 2.42 t/ha when irrigation missed at the beginning of stem elongation, 2.80 t/ha when irrigation missed at the beginning of flowering and 2.55 t/ha when irrigation missed at achene development.

Seghatoleslami et al. (2012) conducted a study the effect of irrigation on yield of sunflower. The study showed that irrigation significantly affected the sunflower yield. The yield was 1.3 t/ha at 33 % supply plant water requirement (PWR), 2.2 t/ha at 67 % supply PWR and 3.5 t/ha at 100 % supply PWR.

Chaves et al. (2015) determined the effect of irrigation on sunflower yield. The experiment was carried out at four available soil water (ASW) levels (55%, 70%, 85% and 100%) where the 100 % ASW level produced the highest yield.

In Bangladesh, some studies have been carried out in the past the effect of irrigation water management on the yield of sunflower in coastal areas.

BARI conducted a set of trials in the farmers' fields of four upazilas: Noakhali Sadar, Subarnachar, Hatyia and Kamalnagar of Noakhali district for two years. Seasonal changes in soil salinity were monitored throughout the growing season at regular interval collecting and analyzing soil samples following standard procedures. Sunflower performed better producing yield at moderate to high levels of salinity (8.0-12.0dS/m). The yield was 0.6 t/ha when 10.8 dS/m salinity level at flowering stage (CGP Project, 2011).

Mondal et al., (2013) observed the yield of sunflower (Hysun- 33) under three irrigations in the southwest Bangladesh and the yield was 1.5 t/ha.

Rashid et al. (2014) conducted a study on sunflower following un-ploughed and ploughed dibbling during the dry season in 2012 at Katianangla village in Batiaghata Upazila of Khulna District (22°40′N and 89°31′E) in Bangladesh. The soils of the experimental fields at 0-15cm depth were clay loam in texture, with a pH of 8.10, organic C of 6.44 g/kg, total N of 1.0 g/kg, available P of 4.55 mg/kg, exchangeable K of 0.40 meq/100 g, available S of 75.78 14 mg/ kg, and Zn of 1.27 mg/kg. The plots under first date of seeding were irrigated once, whereas others were not irrigated due to occurrence of rainfall at the stage for fertilizing the crops. On 14 January, soil salinity (dS/m) of sunflower fields was 4.4 dS/m, 4.6 dS/m, 5.8 dS/m, 7.7 dS/m, 8.0 dS/m and 8.6 dS/m at 15 days after sowing (DAS), 30 DAS, 45 DAS, 60 DAS, 75 DAS and 90 DAS. On 22 February, soil salinity (dS/m) of sunflower fields was 6.0 dS/m, 6.6 dS/m, 7.6 dS/m, 8.6 dS/m, 9.2 dS/m and 9.5 dS/m at 15 days after sowing (DAS), 30 DAS, 45 DAS, 60 DAS, 75 DAS and 90 DAS. Due to sowing date on 14 January, the yield was 3.1 t/ha and BCR was 2.3. Due to sowing date on 22 February, the yield was 2.7 t/ha and BCR was 1.8.

Sarker et al., (2014) observed the yield of sunflower ranged from 2.3 to 3.7 t/ha, respectively, over the two years, similar to the findings of others in the coastal zone and in other parts of Bangladesh.

Mila et al., (2015) conducted an experiment in the research field of Agricultural Research Station, Benarpota, Sathkhira during the Rabi season of 2014-2015 with BARI Surjomukhi-2. There were nine irrigation treatments, each replicated thrice in a randomized complete block design with additional spare plot. About 30% water was saved to produce 2.52 t/ha yield by applying 60% deficit irrigation up to FC at vegetative and pre-flowering stage which had increased WP and economics. It was also found that pre-flowering stage was the critical stage to deficit irrigation.

2.4 Irrigation Water Management on the Yield of Sesame in Saline Areas

Internationally some studies have been carried out in the past the effect of irrigation water management on the yield of sesame.

Boydak et al. (2007) determined the effects of irrigation intervals on sesame yield. The yield was 0.13 t/ha, 0.12 t/ha, 0.14 t/ha and 0.10 t/ha at 6, 12, 18 and 24 days irrigation interval.

Hassanzadeh et al. (2009) conducted a study, the effect of irrigation levels (complete irrigation and irrigation until flowering) on sesame yield. The results showed that the yield was 0.7 t/ha at complete irrigation and 0.4 t/ha at drought stress.

Ali et al. (2013) conducted a study that the effect of irrigation intervals on yield of sesame. Supplied of water with 9 days irrigation interval produced highest (0.9 t/ha) seed yield while lowest (0.6 t/ha) seed yield was obtained from 27 days irrigation interval.

Nadeem et al. (2015) conducted a field study to evaluate the yield of sesame under the influence of irrigation regimes. The experiment was on three irrigation regimes (2 irrigations at 20 and 40 DAS, 3 irrigations at 20, 40 and 60 DAS and 4 irrigations at 20, 40, 60 and 80 DAS). The seed yield was 0.69 t/ha with 2 irrigations, 0.73 t/ha with 3 irrigations and 0.75 t/ha with 4 irrigations.

In Bangladesh, a few studies have been carried out in the past the effect of irrigation water management on the yield of sesame in coastal areas.

Yousif et al., (1972) conducted a study on sesame and reported that sesame is a moderately tolerant crop to sodium chloride salinity.

Kaul et al., (1986) conducted a study on cultivation of sesame and reported that there is a scope for cultivation of Sesame in the coastal saline areas in the kharif-1 season with rain fed or residual soil moisture.

Pathan et al., (2002) conducted a field trial in the saline region at Benarpota of Satkhira District (AEZ 13) to investigate the mineral nutrition and yield of four varieties of sesame in kharif-1 season of 2002. The varieties were BARI Til-2, BARI Til-3, T-6 and local (red). The soil and irrigation water salinity at sowing were 2.63 and 2.01dS/m, respectively. Among the varieties, the T-6 produced the highest seed yield (1.7 t/ha) and BARI Til-3 (0.7 t/ha) did the lowest. Irrigation was done only before sowing and the EC value was 2.01 dS/m.

2.5 The Livelihood Security Index for Farmers

Several studies have been carried out in the past in a number of countries on the livelihood assets of people. But few studies have been carried out on the development of the farmers' livelihood security index.

The concept of livelihood is dynamic, recognizing that the conditions and composition of people's livelihood changes, sometimes rapidly, over time. Livelihoods are complex, with households in the developing world undertaking a wide range of activities (Ellis, 1998). Livelihood is synonymous to occupation that means to sustain a person or a household. This includes a range of occupations/activities, such as farming, fishing, industry, etc., that generate proceeds, income and wealth. Livelihood assets create the base for livelihood options and activities for a household (PDO-ICZMP, 2002).

According to the Sustainable Livelihood Framework, all household assets/resources are broadly grouped into five categories, which include: human, natural, financial, technical and social/institutional resources (Carney, 1999). Ownership/control of or access to these assets/resources is vital for decision making for livelihood activities. A livelihood comprises of the capabilities, assets (stores, resources, claims and access) and activities required for a means of living; a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets and provide sustainable livelihood opportunities for the next generation: and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term (Chambers and Conway, 1992). The stability of people's livelihoods depends largely on their vulnerabilities and the resources that they depend on and Livelihoods must differ in different social, ecological and institutional settings. The coastal livelihood analysis provides a better understanding of coastal livelihood conditions at present and in future. This understanding has been instrumental in preparing a meaningful coastal zone policy, and would guide the formulation of a pragmatic coastal development strategy and a feasible investment program for enhancement of livelihoods of the coastal people, particularly the disadvantaged groups (PDO-ICZMP, 2004).

Singh et al. (2010) presented an overview of the existing indicators of development and positions them within the environmental, economic, and social dimensions of sustainable development. It presented empirical evidence of sustainable livelihood security index (SLSI) at the district level in Gujarat. SLSI is a composite index having three component indices, i.e. the ecological security index (ESI), the economic efficiency index (EEI), and the social equity index (SEI). The SLSI based on its simplicity and flexibility, is one of the most comprehensive yet simple indices for measuring long-term livelihood security in rural areas. The SLSI not only identified the general priorities for development, but also the nature and types of policies to be pursued in each study unit to enhance livelihood security. The SLSI facilitated consensus among different partisan groups like economists, environmentalists, and egalitarians by balancing their mutual concerns, providing guidelines for achieving sustainable development.

Narayani et al. (2011) conducted a study on livelihood security of farmers in Virudhunagar district of Tamil Nadu. The livelihood requirement of medium farmers was Rs.87775 per annum followed by big (Rs.86462.50) and small (Rs.74040) farmers. The big farmers spent Rs.78037.50 per annum on different items of livelihood followed by medium (Rs.59835) and small (Rs.44335) farmers. The mean livelihood security index of big farmers was 90.26 per cent of their requirement followed by medium (68.17%) and small (59.88%) farmers. In case of pooled sample, the livelihood security index of majority (75%) of the farmers was between 50 and 100 per cent. Around, 75 per cent of the small, medium and big farmers had medium to high level of a livelihood security index.

Chinnadurai et al. (2012) constructed livelihood security index of the households by identifying the existing agricultural and non-agricultural activities of all the 120 sample households classified under marginal, small and medium households. The study revealed that income from agriculture and allied activities formed the major share (86.7per cent) of the sample households with medium landholdings, and lowest among marginal households (42.62per cent). In general the overall livelihood security index was high among medium (53.65 per cent) when compared with small (46.43 per cent) and marginal households (38.44 per cent).

Dadabhau et al. (2014) developed an index for assessing the livelihood security status of farmers. In the study, seven different dimensions of livelihood security, i.e. food security, economic security, agricultural security, health security, social security, and infrastructure security and environmental security were collected through relevant literature scan and consultation with experts. A total of 50 indicators was considered for the index development. The different dimensions of livelihood security were sent to 40 judges who were experts of relevant field for their ranking according to their importance in the livelihood security of small and marginal farmers. The scale values were calculated for different dimensions of livelihood security by the normalized rank order method suggested by Guilford (1954). The relevant indicators of each dimension of livelihood security were selected according to their respective relevancy weight age and mean relevancy score. Finally, a composite integrated rural livelihood security index was developed for assessing the livelihood security status among small and marginal farmers.

In Bangladesh some studies have been carried out in the past on the livelihood system analysis of coastal people, but no literature is found in the development of livelihood security index for farmers in the coastal area.

In Bangladesh Livelihood in the coastal area differs from the rest of the country and more than a quarter of the population of the country lives in a coastal environment with multiple vulnerabilities and opportunities (CDP, 2003). Population density in the coastal districts is slightly higher than the national average, and the rate of increase is also similar to the national trend (BBS, 2001).

Uddin et al., (2011) observed lower crop production was due to lower productivity of land caused by salinity. Crop yield has been reduced in all the regions. Farmers' income was increased which enhanced overall socioeconomic condition and livelihood status. Their technical knowledge, social network, housing and sanitation facilities, communication facilities, cash income and savings, managerial capacities, etc. were improved. However, farmers' health condition was deteriorated to some extent due to disease outbreaks, scarcity of safe drinking water, etc. Majority of the respondents had decreased access to forest resources due to increasing salinity impacts of shrimp farming. Educational status of the majority of the respondents was enhanced. Household asset possession was increased. The number of dwelling houses, household furniture's, luxury items like mobile phone, TV, fan, refrigerators, etc. was increased.

2.6 Profitability Analysis of Boro Rice, Sunflower and Sesame Crops:

Several studies have been carried out in the past in a number of countries on the Benefit-Cost Ratio (BCR) ratio of sunflower and sesame crops.

Rashid et al., (2003) studied to see the productive efficiency of different sunflower in a research area of Faisalabad. The results of the studies indicated that 2.89 t/ha yield, 29718.75 Rs/ha net income and 3.18 BCR.

Duhoon et al., (2004) studied on the optimization of sesame production through the use of bio/natural inputs conducted at four centers of All India Coordinated Research Project, during 2002-03 and 2003-04 revealed that among 12 treatments with recommended dose of nutrients through different combinations of bio/natural inputs. The B.C. Ratio was 2.66.

Abu et al., (2012) analyzed productive efficiency among sesame farmers in Nasarawa State of Nigeria. The analysis of technical efficiency revealed that farm size and chemical were not significantly related to technical efficiency while seed, labor and fertilizer were statistically significant to technical efficiency. The mean economic efficiency was 94.5% and the minimum and maximum were 10.0 and 91.5%, respectively.

Raikwar et al., (2013) conducted a study at 65 farmers' field, to demonstrate production potential and economic benefit of improved technologies comprising short duration. The improved technology recorded a mean yield of 5.34q/ha which was 34% higher than that obtained with farmers practice yield of 3.45q/ha. The improved technologies resulted higher mean net income of Rs.12913.80/ha with a benefit cost ratio of 2.49 as compared to local practice (7740/ha, 2.20).

Some studies have been carried out in the past on the farmer's income and production related to livelihood assets in the coastal area of Bangladesh.

Kana et al., (2011) conducted a study on the profitability of salt tolerant BINA Dhan-8 production in the coastal Satkhira district of Bangladesh. Per hectare net returns of BINA Dhan-8 rice was Tk. 72414.02/ha in the coastal Satkhira district of Bangladesh and BCR of BINA Dhan-8 rice was 2.46.

Sanjida et al., (2014) observed adoption of salt tolerant variety in the Coastal areas of Bangladesh. The findings were that the innovation has always risked. Sometime new technology used to fail in coping with new areas because of failure. The farmers having large farm size can take this risk as trial basis and if they fail, they can compensate through other rice varieties. On the other hand, small farmers have no scope of taking risks for which they have to wait for a while in adopting new technology. Therefore the farmers having more annual income could able to take the risk of an extensive coverage. Those indicated that more annual income of the farmers increased a tendency on the way to more adoption of Salt tolerant variety of BRRI Dhan-47. This indicated that innovativeness of farmers could influence their adoption behavior towards BRRI Dhan-47. Higher innovativeness is an individual inspires to adopt new technology. For This reason innovative farmers face less problems in adopting new agricultural practices. The extension media conduct of the farmers had a significant effect with their adoption of BRRI Dhan-47. Hossain (2006) and Chowdury et al. 2012 reported that the similar results found in the respective study. This indicated that the farmer whose regularly conduct with extension workers, adoption rate of BRRI Dhan-47 was higher than irregular conduct with extension worker. The knowledge of rice cultivation of the farmers had a significant effect with their adoption of BRRI Dhan-47. Chowdury et al. 2012 indicated that farmer's knowledge of rice cultivation increases the adoption of BRRI Dhan-47 among the respondents.

Khan et al., (2009) conducted at Agricultural Research Station, Comilla during summer (Kharif) season, 2009 to estimate the proportionate yield and economic loss of sesame due to different management factors and to identify major factors of yield loss reduction of sesame. From the results of the experiment, it was found that the yield reduction of sesame variety BARI Til-3 was reduced over the recommended package of practices by 24.6%, 15.10%, 15.05% and 7.40% from the treatments with delay sowing, no seed treatment, no insect control and no disease control respectively. The highest net return (Tk.18320/ha) was obtained from the treatment with recommended package. The highest economic loss Tk. 11840/- was recorded from the treatment with delay sowing and the second highest economic loss Tk. 6980/- was found from no seed treated plot. The highest yield (1595.67 kg/ha) was found from full package treatment followed by no fungicide treatment (1477.33 kg/ ha) and the lowest yield (1201.3 kg/ha) was found from delay sowing treatment.

2.7 Indicator Development of Livelihood Assets:

An indicator is a parameter or a value derived from parameters, which points to; provides information about and describes the state of an environment with significance extending beyond that directly associated with the parameter value (OECD, 1998). Indicators are used to systematize the definition and description of information needs and collection of information from different national, international, institutional management levels. An indicator can be defined as a variable or an aggregate set of variables giving information of a system, process, or state and which has significance beyond its face value. Indicators simplify, quantify and communicate information for a variety of purposes, including policy assessment and development. The Indicator must help to clarify objectives and set priorities; they are explanatory tools (Hardi & Barg, 1997; World Bank, 1997) which contribute to the translation of the sustainability concept into practical terms. Indicators are becoming increasingly important in summarizing progress of development-related activities and researches. However, there continues to be a lack of consensus on both definition and application of indicators. Whilst there is basic agreement that indicates "serve to indicate or give a suggestion of something; an indication", there is still disagreement as to what form that indication takes. Another area of disagreement is over the respective merits of qualitative or quantitative indicators (Chadwick e*t al,* 2003).

Chapter Three

Research Methodology

3.1 Introduction

The study was conducted in two polders namely Polder 31 (Chalna, Pankhali and Tildanga unions) and Polder 32 (Kamarkhola and Suterkhali unions) of Dacope Upazila of Khulna district during the Rabi season in 2013-2014. The polders are vulnerable to tidal and storm surge flooding and Polder 32 was cyclone Aila affected and Polder 31 was non-affected. Because of long term inundation from intruded saline water due to Aila, there are differences in cropping pattern between the two Polders. But, in both the Polders, the scarcity of irrigation water, soil and water salinity are the major constraints for growing irrigated crops. So, the farmers cannot grow irrigated crops largely due to soil salinity and lack of fresh water. In spite of these problems, farmers are taking crop growing decisions in a water scarce environment. Some farmers grow Boro rice and others grow Rabi crops like sesame, sunflower, watermelon, etc. and some keep their lands fallow. After the crop selection, different water management practices are adopted by farmers to grow their crops. There are relationships between the cropping decisions, water management practice, yield and income. In other word, the cropping decisions affect the farmers' livelihoods in the study area.

3.2 The Study Area

3.2.1 Location and Area

The Dacope Upazila is located in the South-Western region of Bangladesh. The study area is situated in latitude of 22.5722°N and longitude of 89.5111°E.The Upazila is bounded on the North by Batiaghata Upazila, on the East by Rampal and Mongla Upazila of Bagerhat district, on the South by the Sundarban Mangrove Forest and the Bay of Bengal and on the West by Koyra and Paikgachha Upazila. The total area of the study site is 27228 hectares and the number of population is approximately 159851. The location map of the study area is shown in Figure 3.1.

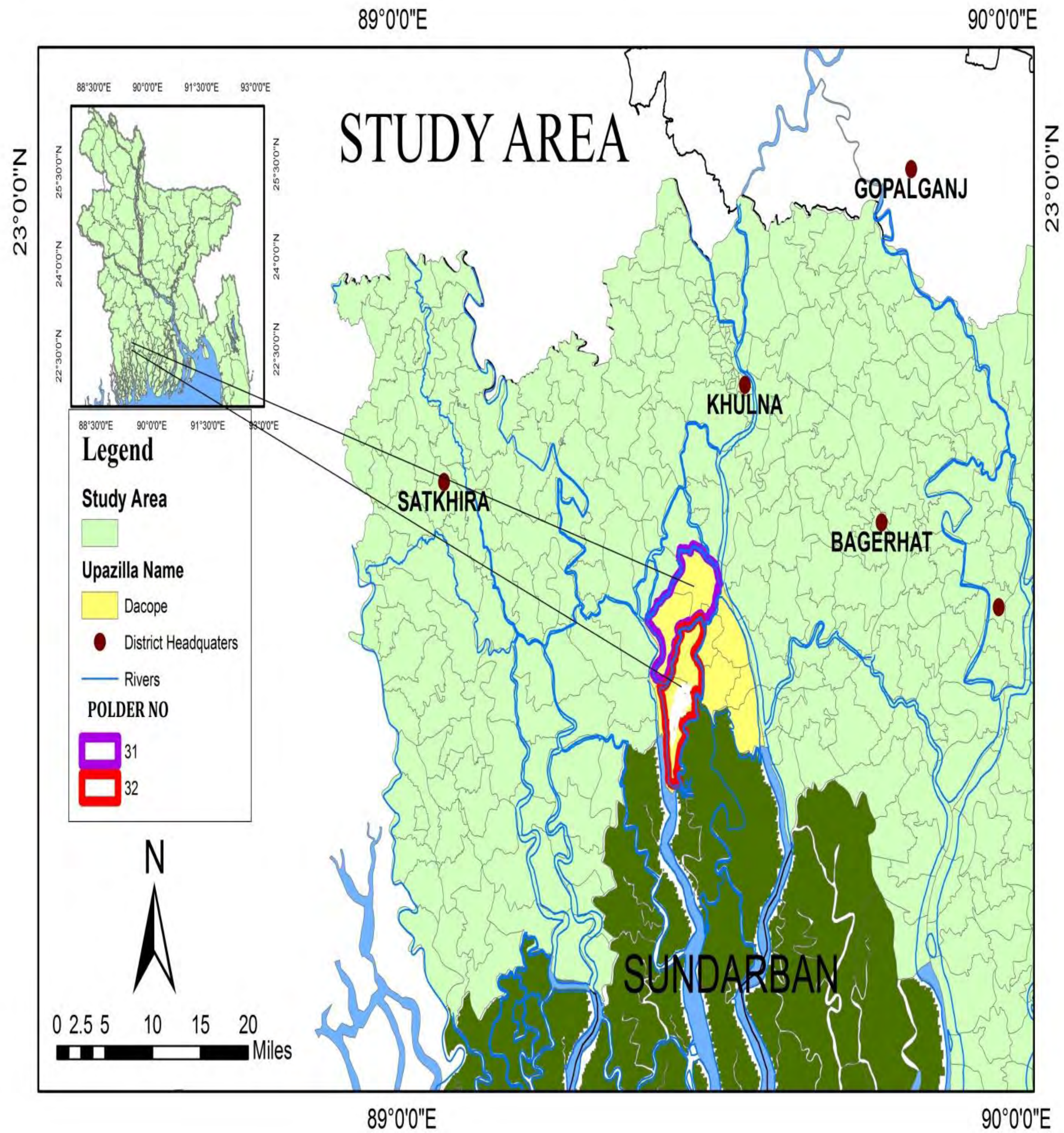


Figure 3.1: Location of the study area in southwestern coastal region of Bangladesh

The study was carried out in six villages (Pankhali Union, Polder 31), three villages (Tildanga Union, Polder 31), three villages (Suterkhali Union, Polder 32) and six villages (Kamarkhola Union, Polder 32) at Dacope Upazila during the Rabi season of 2013-2014. For the development of the decision model, forty sample farmers' were randomly selected. The field survey was conducted on the selected farmers. The survey results show that among these forty farmers 16 grew sunflower, 6 grew sesame, 8 planted Boro rice and the rest 10 kept their land fallow. The selected farmers represent almost one fifth of the total farmers of the selected four villages. The decision model was developed by surveying 30 farmers (75% of the sample) in seven villages. After development of the decision model, it was tested at the field level by surveying the rest 10 farmers (25% of the sample).

3.2.2 Geology and Soil

The study area lies under Agro-ecological zone: Ganges Tidal Floodplain (AEZ -13). The soils are formed from clay-loam, loam and clay sediments, and are seasonally flooded, poorly drained except soils of highland areas. In Pankhali union, the soils possess very low to medium saline condition in the dry season and soil salinity and soil pH level ranges from about 2.5-8.0 dS/m and 5.5-7.0 respectively. In Suterkhali union, the soils possess high to very high (14-30 dS/m) saline condition in the dry season and soil pH level ranges from 6.5-8.0. The amount of organic substance is 0.65%. In this soil, the amount of calcium, magnesium and phosphorus are 18.2 m equivalent/100gram, 12.8 m equivalent/100 gram and 101.2 microgram/gram, respectively, whereas the amount of nitrogen is 0.06% (SRDI, 2014).

3.2.3 Climate

Dacope has a tropical climate. The summer begins from the middle of April and continues till the middle of June. The winter starts from November and continues till February. Variations of temperatures, humidity, and annual rainfall, wind (speed and direction) during 2011-2014 periods were collected from the Bangladesh Meteorological Department (BMD). The annual mean temperatures in Khulna varied from 24.3^0C to 26.8^0C within the 2011 to 2014 period. The highest maximum and lowest minimum temperatures were recorded as 36.7 ^{O}C (May, 2012) and 11.7 ^{O}C (January, 2013) respectively. The level of humidity rises to 89 percent in the month of July which commences from the middle of June and continues till the end of September. The rainfall is generally heavily in the month from June to September. The annual total, maximum and minimum rainfalls were recorded as 206.4 mm (2013) and 164.5 mm (2012) for the study area. Monthly prevailing wind speeds varied from 1.5 knots in eastern direction to 4.3 knots in south direction, respectively (BMD, 2014).

3.2.4 Land Use Pattern

The total cultivable area of Dacope Upazila is 20985 hectares occupying about 84.09% of the total area of the Upazila. The temporary fallow land in the study area is 16677 hectares during the Rabi season. In this area, 79% of cultivable lands are medium highland or F1 (flooded depth of 90 cm from two weeks to three months) and 11% is medium lowland or F2 (90-180 cm flooded continuously for several months). The land type classification based on cultivable land of Dacope Upazila as collected from the Upazila Agricultural Office is presented in Table 3.1.

Table 3.1: Cultivable land type classification in the study area

Serial no	Land type	Land area (ha)	% of total land
01	Highland	1531	08
02	Medium high land	15629	79
03	Medium low land	2255	11
04	Low land	415	02
05	Very low land	0	0

Source: Upazila Agriculture Office, 2013

3.2.5 Agricultural Crops and Cropping Pattern

The crops cultivated in the Dacope Upazila are: T. Aman (HYV/LIV), Boro (HYV/LIV), Aus (HYV/LIV), sesame, sunflower, watermelon, coriander, maize, coconut, papaya, etc. The major cropping patterns of the study area are T. Aman-Rabi crops-Fallow, T. Aman-Rabi crops-Aus etc. The cropping intensity of Dacope Upazila is 120 % (DAE, 2011).

3.2.6 Area and Yield of Boro Rice and Non-Rice Crops

The cropping pattern of different crops of Dacope Upazila as collected from the Upazila Agriculture Office is presented in Table 3.2. After cyclone Aila, the sunflower was a newly introduced crop in the Dacope Upazila. Due to lack of adequate fresh irrigation water and presence of soil and water salinity during the Rabi season, the sunflower was practiced in the Upazila. The cropping pattern was T. Aman-Sunflower- Fallow for the sunflower crop producing farmers. Among the Boro rice, the BRRI Dhan-47, BINA Dhan-8 and Shakti-2

(BRAC-5) varieties were cultivated depending on the source of irrigation water, amount of irrigation water, yield, income and salt tolerance during the Rabi season. These farmers followed the T. Aman-Boro rice- Fallow cropping pattern. When the residual moisture content was the only opportunity then they grow sesame, the farmers followed the T. Aman-Sesame-Fallow cropping pattern. Due to above reasons the T. Aman- Boro rice- Fallow, T. Aman- Sunflower- Fallow and T. Aman- Sesame – Fallow cropping pattern is considered in the study area and the amount of land is 65 ha, 90 ha and 16 ha respectively.

Table 3.2 Cropping patterns in the study area

Kharif-2	Rabi	Kharif-1	Amount of Land (ha)
T. Aman	Boro rice	Fallow	65.0
T. Aman	Sunflower	Fallow	90.0
T. Aman	Sesame	Fallow	16.0
T. Aman	Watermelon	Aus	600.0
T. Aman	Watermelon	Fallow	1525.0
T. Aman	Fallow	Aus	100.0
Fallow	Vegetables	Vegetables	175.0
T. Aman	Vegetables	Fallow	350.0
T. Aman	Fallow	Fallow	15996

Source: Upazila Agriculture Office, 2011

The area and yield of Boro rice, sesame and sunflower (Hysun-33) crops of Dacope Upazila as collected from the Upazila Agriculture Office are presented in Table 3.3. In the study area the farmers started to cultivate the sunflower and BINA Dhan-8 during the Rabi season of 2013-2014.

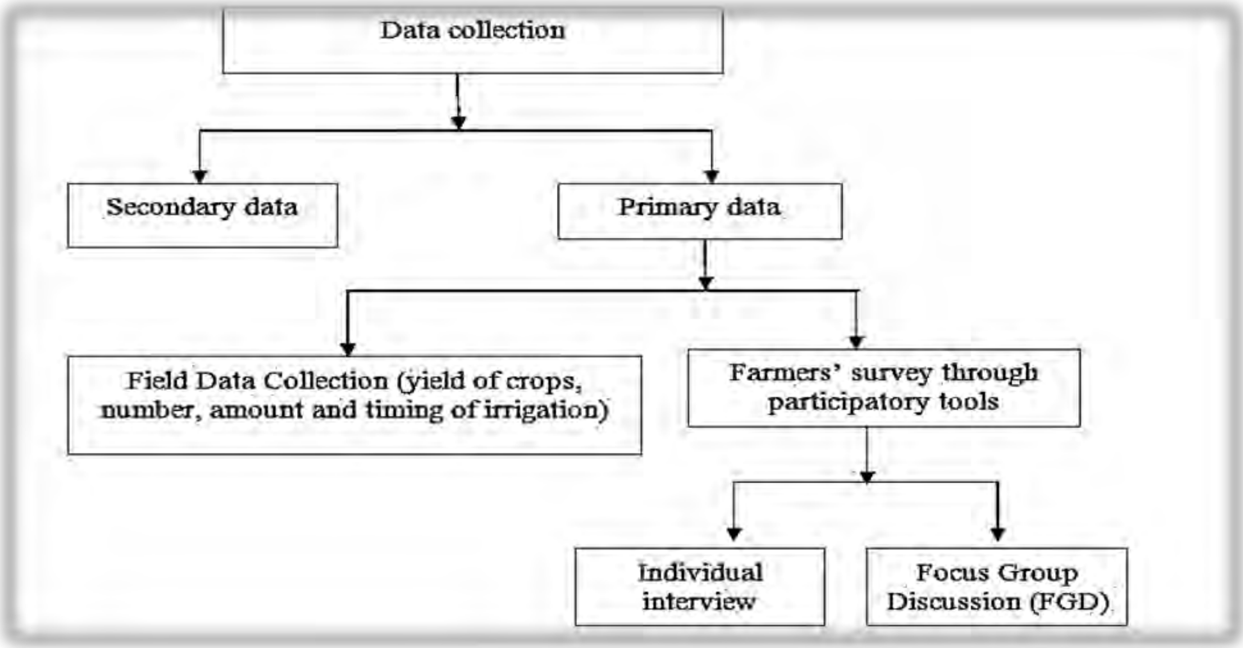
Table 3.3 Area and yield of Boro rice and non-rice crops during the Rabi season of 2013-14 in Dacope Upazila

Item	Cultivated land (ha)			Average Yield (t/ha)
	Dacope Upazila	Pankhali Union (Polder 31)	Suterkhali Union (Polder 32)	
Boro rice	65	12	3	4.3
Sunflower	90	15	2	1.7
Sesame	16	2	1	0.8

Source: Upazila Agriculture Office, 2013

3.3 Data Collection

The study was conducted based on both primary and secondary data sources. The primary data were collected based on reconnaissance survey and farmers' survey. The farmers' survey was conducted by individual interview and Focus Group Discussion (FGD). Data collection of this study was conducted through the following methods:



3.3.1 Literature Review and Secondary Data Collection

Secondary data regarding location and geography of the study area, demography, land use, cropping pattern and farmers' livelihood practices in the selected study area were collected from relevant books, Newspaper reports and publications. Other required specific information were collected from different published and unpublished reports/research reports/journals of Bangladesh Bureau of Statistics; Bangladesh Meteorological Department; Bangladesh Agricultural Research Institute; Bangladesh Rice Research Institute; Bangladesh Institute of Nuclear Agriculture, Department of Agriculture Extension; Upazila Agriculture Office of Khulna; Bangladesh Water Development Board; Bangladesh University of Engineering and Technology; Bangladesh Agricultural Research Council; DFID Framework; River Research Institute; relevant websites and other government and non-government organizations.

3.3.2 Primary Data Collection

A combination of methods has been used for primary data and information collection. The principal methods used were directly observed, individual interview, key informant interview and focus group discussion (FGD), etc.

Farmers' Survey

The farmers' survey has been conducted in exposed cyclone affected (Polder 32) and cyclone non-affected (Polder 31) coastal part of south-west (Khulna) coastal district to determine the crop selection, irrigation water management and farmers' livelihood of the study area. The major concern areas in the survey were:

- Boro rice, Rabi crops and cropping pattern
- Cyclone Aila affected and cyclone Aila non-affected
- The extent of soil salinity during Rabi (dry) season in study area
- The extent of water salinity in the water body during Rabi (dry) season
- The irrigated crops and non-irrigated crops
- The use of irrigation system
- The source of irrigation water, the number, timing and amount of irrigation water
- The yield of Boro rice and Rabi crops (sunflower and sesame) from farmers practice
- The condition of farmer's livelihood

The farmers' survey through participatory tools (individual interview and focus group discussion) was conducted in each of the two polders to understand how the farmers' decide about growing Rabi crops and which crop to grow and to understand the impacts of crop selection on the livelihood of the farmers. In addition, there was a checklist for individual interview and focus group discussion (Appendix-A) for finding some special information from officials and people work with relevant issues in that area.

Individual Interview (II)

Individual interview of farmers was used to understand the farmer's decision regarding crop selection and water management of Boro rice and non-rice crops in Polder 31 and Polder 32 area during Rabi (dry) season (as shown in Photo 3.1). For the development of the decision model, forty sample farmers' were randomly selected. Among these forty farmers individual interview was conducted.

Focus Group Discussion (FGD)

Focus group discussion (FGD) was conducted to receive qualitative information as to understand the impacts of crop selection on the livelihood of the farmers (as shown in Photo 3.2). In each Polder, nine FGD's were conducted with the farmers. The location map of the FGD is shown in Appendix-B. About 161 participants (69 in Polder 31 and 92 in Polder 32) were participated in the FGD (Appendix-B). The indicators of livelihood assets (Social, Human, Natural, Financial and Physical) were selected from FGDs. The FGD was conducted to find out the actual value, standard value of indicators as well as to elicit appropriate weights to the various indicators. This information was used to illustrate the pentagon of the five components of livelihood assets of the crop producing farmers both in Polder 31 and Polder 32. The Farmers Livelihood Security Index (FLSI) was developed on the basis of FGD using the standard value of indicators and appropriate weights to the various indicators. The FGD was conducted on Boro rice producing farmers, sunflower producing farmers, sesame producing farmers and fallow land farmers separately.

Field Data Collection:

The number, amount and timing of irrigation were collected from farmers' for the selected (Boro rice, sunflower and sesame) crops. Yield and yield components, data and crop- cut information in Rabi season were collected from the farmers. The data of production cost and price of crops at harvesting period were collected from the farmers.

Key Informant Interview (KII):

Key informant interview (KII) was used to include the views of experts in the data collection (as shown in Photo 3.3). For the knowledge of before and existing situation of Dacope Upazila about soil salinity, water salinity condition, agricultural cropping pattern information, etc. the discussion was conducted with SRDI, BARI, DAE, BWDB, BMD, BRAC and Blue gold office personnel.

Photo 3.1: Individual interview with farmer

Photo 3.2: Focus Group Discussion (FGD) with farmers

Photo 3.3: With Key Informants (scientists) from Agricultural Research Station (ARS), BARI, Khulna

Source: Field Survey, 2013-14

3.4 Farmer's Decision Model on Crop Selection

A descriptive model on decision to grow a Rabi crop and a selection of the Rabi crop was developed based on the information collected from the individual interview with the farmers. The decision criteria were then modified using a decision tree, which was then again tested on the farmers to predict the decisions made by them and also to ascertain the validity of the developed models. Such descriptive models have been developed in the past to understand how farmers make decisions in the real world and the steps they go through in the process (Intal and Valera. 1990; Lampayan et.al., 1994 and Saleh et al., 2002).

3.5 Determination of Soil Salinity and Water Salinity

For the assessment of salinity level, the electrical conductivity (EC) has been used as parameter. The soil electrical conductivity (EC) was measured from the saturation extract (Chapman, 1961). Soil samples were collected from the fields before sowing of sesame and sunflower seeds, and after transplanting of Boro rice to measure the EC of soil. Soil samples were also collected from fallow lands. The soil samples were collected in January, February, March, April, and May. The portable EC meter was used for measuring water salinity in the canals, pond and on-farm reservoirs.

3.6 Determination of Soil Moisture Content

The gravimetric method (weight basis) was used for measuring soil moisture content.

3.7 Determination of Irrigation Water Requirement

Irrigation Water Requirement of Boro Rice:

The main irrigated crop in the study area is the Boro rice (irrigated winter rice). For the determination of irrigation water requirement of Boro rice, the following criterion was considered:

1) Determination of Potential Crop Evapotranspiration (ET_c): For the determination of Potential Crop Evapotranspiration (ETc), the Penman-Montieth method using CROPWAT software developed by FAO (Smith, 1992) was used. The Potential crop evapotranspiration (ETc) was obtained from the following relationship (Doorenbos and Pruitt, 1977).

$$ET_c = ET_0 \times Kc \qquad (1)$$

Where, ET_0 is the evapotranspiration measured by CROPWAT in mm/day and Kc is the crop coefficient. The Kc values were obtained from FAO Bulletin of Statistics (FAO, 2001). The crop coefficient (Kc) for different growth stages of Boro rice were considered as 1.1 for vegetative stage (60 days), 1.25 for reproductive stage (30 days) and 1.0 for ripening stage (30 days).

2) Seepage and percolation (S&P) rate for different growth stages were obtained from FAO Bulletin of Statistics (FAO, 2001).
3) Effective Rainfall (ER) is the precipitation occurred during the growing period of crop that is available to meet the evapo-transpiration needs of the crop. It does not include precipitation lost through deep percolation below the root zone or the water lost as surface run-off. As in the dry season, the precipitation is very minimal, it was assumed (80% probable rainfall) a fraction of the dependable rainfall is considered as effective rainfall.
4) Net Irrigation Water Requirement (IWR) was estimated using the following relationship.

$$IWR = ETc + S\&P - ER \qquad (2)$$

Where, ETc = crop evapo-transpiration (mm/day),

S&P = seepage & percolation (mm/day) and

ER = effective rainfall (mm/day).

5) The water requirement for land preparation (LP) in the study area was considered 200 mm (Alam, 2011). The irrigation water requirement,

$$IWR = (CWR - R_E) + LP \quad (3)$$

$$IWR = (ET + S\&P - R_E) + LP \quad (4)$$

6) The Field Irrigation Requirement (FIR) was calculated by considering 60% irrigation efficiency (Alam, 2011).

$$FIR = IWR / \text{irrigation efficiency} \quad (5)$$

Irrigation Water Requirement of Sunflower:

Another irrigated crop in the study area is the sunflower (Variety: Hysun-33). For the determination of irrigation water requirement of sunflower, the following criterion was considered:

1) The crop water requirement (CWR) of sunflower was obtained using following equation.

$$CWR = ET_{CROP} \quad (6)$$

Where, $ET_{CROP} = ET_0 \times K_C$

Like Boro rice, ET_0 was estimated by Penmen-Monteith method (CROPWAT). The crop coefficient (Kc) of sunflower for different growth stages was considered as 1.0 for vegetative stage (30 days), 1.5 for pre-flowering stage (30 days) and 0.35 for heading stage (30 days) (FAO, 2001).

2) The irrigation water requirement (IWR) was obtained using following equation.

$$IWR = ET_{CROP} - R_E \quad (7)$$

Where, R_E is the effective rainfall.

3) The field irrigation water requirement was estimated using following equation.

$$IWR_{FIELD} = IWR / \text{Field Application Efficiency } (E_F) \quad (8)$$

The Field Application Efficiency (E_F) was considered as 60% (Alam, 2011).

3.8 Economics Analysis of Boro rice, Sunflower and Sesame Crop

For the assessment of production/unit area, use of inputs and profitability of rice and non-rice crops, individual interview was conducted on 20 farmers (10 farmers for sunflower, 4 farmers for sesame and 6 farmers in Boro rice) including the 10 farmers selected for in- field study. For an assessment of the profitability of the crops, a benefit-cost analysis was carried out based on the data collected from the farmers' survey. In this study, the fixed cost, such as, land rent, taxes and interest on the value of land have not been considered in the total cost, and only variable cost (human labors, land preparation, seeds, fertilizer, insecticides, processing, irrigation etc.) were taken into consideration.

3.9 Livelihood Analysis of Boro rice, Sunflower and Sesame Crop Producing Farmers

Focus Group Discussions (FGD) was conducted with Boro rice, sunflower and sesame producing farmers as well as fallow land farmers in each of the two polders.

3.9.1 Selection of Farmers in the Study Area

During the Rabi season, cultivation of Boro rice and most of the non-rice crops are dependent on irrigation. So, the farmers cannot cultivate irrigated crops largely due to lack of fresh water and soil salinity. In spite of these problems, farmers of polder 31 and polder 32 are taking crop growing decisions in a water scarce environment. Some farmers grow Boro using the canal and on-farm reservoir (OFR) as a source of irrigation water. Some farmers cultivate sesame under rain fed condition; some farmers cultivate sunflower using OFR as a source of irrigation water and some keep their lands fallow.

The farmers have been selected based on the following criterion:

- The Polder 31 was cyclone Aila non affected area. In Polder 32 was cyclone Aila affected area. The most of the farmers of Polder 32 in Suterkhali Union kept their land fallow during Rabi season after Aila due to the lack of fresh irrigation water, soil salinity and lack of capital for the cultivation of Rabi crops. There was a group of fallow land farmers in Suterkhali Union during the Rabi season.
- Some of the farmers' cultivated Boro rice, some cultivated sunflower and some of the farmers cultivated sesame.

3.9.2 Selection of Specific Indicators as Determinants of Farmers Livelihood Security (FLS)

Indicator choice is a complex decision problem involving many criteria (Mutahara, 2009). A total of 13 indicators were selected based on FGD following DFID framework. The selected indicators are: the Access to soil information, availability of effective extension services, availability of new varieties in the market, availability of fertilizer and pesticides in the market, training of the farmers, motivation of the farmers, canal irrigation water , on-farm reservoir or pond irrigation water, profit, yield, access to marketing network, irrigation water facility and amount of irrigation water. A Farmers Livelihood Security Index (FLSI) was developed based on the standardized indicators. The DFID's sustainable livelihood framework (Ashley and Carney, 1999) was used (Scoones, 1998) to frame the identification of indicators that determine farmers' livelihood security. The selected indicators are not only applicable to crop producing farmers in Polder 31 and Polder 32 but also in other polders of all coastal districts.

3.9.3 Standardization and Weighting of Selected Indicators

The selected indicators used in the construction of the farmers' livelihood security index, all indicators were standardized following the UNDP (2007) procedure of standardizing indicators for the index value (equation 9).

$$\text{Index value (standardized value)} = \frac{Actual\ value - minimum\ value}{Maximum\ value - minimum\ value} \quad (9)$$

For the standardization, the actual values of the selected indicators were collected from the farmers through focus group discussion. The actual values were collected response to Boro rice, sunflower and sesame crop producing farmers individually both in Polder 31 and Polder 32. The weight of each criterion has been determined based on field response. The number of times a particular indicator was cited was used to generate the weighting system (Table 4.16 and 4.17). A total of eighteen FGDs have been conducted in the selected study area. First FGDs have been conducted to understand the situation of crop farmers' livelihood security and indicators have been developed from that. The second FGDs have been conducted to find out the actual, minimum and maximum value of indicators by full, half, one-third and two-third ranking of indicators. The checklist for FGD is attached in Appendix-A. The locations and participants list are also attached in Appendix-B. Finally, using these values the standardized values were calculated from equation 9.

All indicators were normalized to have a relative position between 0 and 1 (Vincent, 2004; Hahn et al., 2009). These values were used to illustrate the pentagon of the five components of livelihood assets of the crop producing farmers in Polder 31and Polder 32.

3.9.4 Methodology of Farmers Livelihood Security Index (FLSI) Calculation

The farmers' livelihood security index for producing Boro rice, sunflower, and sesame was calculated using the following model (Vincent, 2004).

$$FLSI = (Ssvi \times Wi) + (Hsvi \times Wii) + (Nsvi \times Wiii) + (Fsvi \times Wiv) + (Psvi \times Wv) \quad (10)$$

Where,

FLSI = Farmers Livelihood Security Index

Ssvi = Standardized value of social asset sub-index

Hsvi = Standardized value of human asset sub-index

Nsvi = Standardized value of natural asset sub-index

Fsvi = Standardized value of financial asset sub-index

Psvi = Standardized value of physical asset sub-index and

Wi terms refer to the weighting that was applied to each standardized value.

Chapter Four
Results and Discussion

4.1 Rabi Crop Decision Model

On the basis of the discussion with the farmers, the checklist and field tests, the decision model on whether to grow a Rabi crop or keep fallow was developed and is shown in Figure 4.1. Each rectangle in the figure represents a decision, which is guided by a Yes (Y) or a No (N) to an action (represented by an ellipse) or to another decision. The decision to grow a Rabi crop is very much dictated by the soil quality and fresh irrigation water availability.

4.1.1 Farmers' Decision Model for Selection of the Boro Rice and Rabi Crops in Polder 31 (Cyclone Aila Non-Affected Area) and Polder 32 (Cyclone Aila Affected Area)

Once the farmer has decided that he is going to grow Boro rice and Rabi crop, then he has to decide about which crop to grow. The decision model about the selection of a rice and non rice crop is shown in the model (Figure 4.1). According to the individual interviews with the farmers, some farmers do not cultivate any crop due to the presence of soil salinity in top soil, lack of fresh surface water for irrigation, lack of residual moisture content and lack of capital for the cultivation of crops. For the validation of the farmers decision model the decision pathway for the selection of Boro rice, sunflower and sesame with case studies both in Polder 31 and Polder 32 is shown in the Appendix-C.

According to the field information, if the farmers find white crust layer on the soil of crop field at the time of sowing Rabi crops, they think that the soil is saline (as shown in Photo 3.4). The farmers observe the growth of trees and vegetables in their homestead to understand the presence of salinity in soil. If the farmers get the extension service for the determination of salinity in soil at the time of sowing Rabi crops.

On the basis of farmers' information, the soil samples were collected from various locations of Polder 31 and Polder 32. The average level of soil salinity was 12 dS/m and more than 12 dS/m at the time of sowing of Rabi crops in the farmers' fallow land area in Polder 31and Polder 32 respectively. So, if the soil salinity is more than 12 dS/m at the time of sowing of Rabi crops, then the farmers decide to keep their lands fallow.

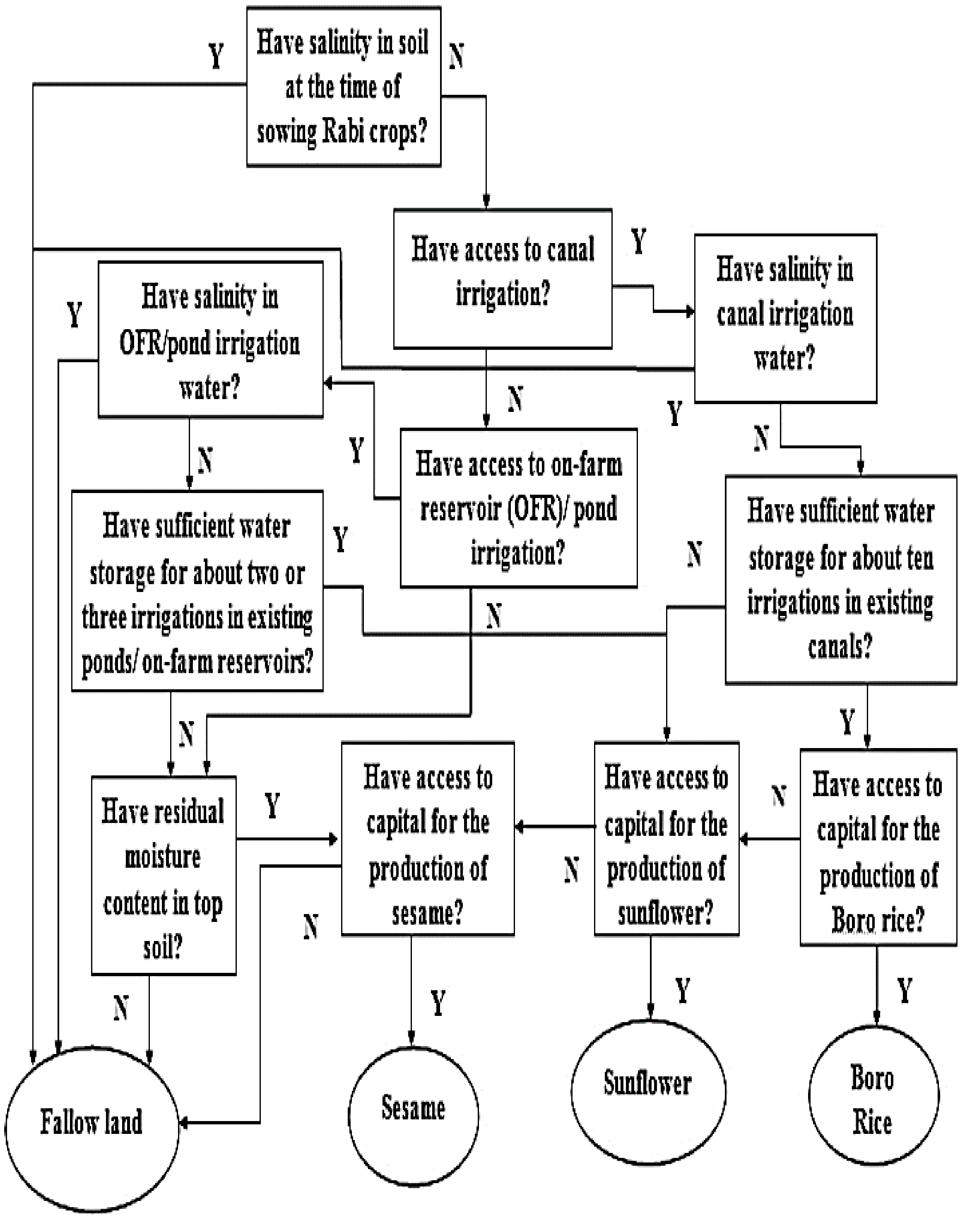


Figure 4.1: Farmers' decision model for the selection of Rabi crops in coastal area

The farmers check the level of water salinity by the application of water in the trees and homestead vegetables. If the growth rate of trees, homestead vegetables and grasses are continuing then they can understand the water is not saline. Again, with the help of agriculture office, NGO and other research person, they can know the level of water salinity. On the basis of farmers' information, the level of water salinity of river, pond, on-farm reservoirs was tested in Polder 31 and Polder 32 (as shown in Photo 3.5) by portable EC meter. The level of water salinity was 11dS/m and more than 11dS/m of canal in Polder 31 and Polder 32 respectively. So, if the salinity is more than 11dS/m in irrigation water, then the farmers' find that the irrigation water is not fresh. The limiting values of salinity are 12dS/m in soil and 11dS/m in irrigation water.

Photo 3.4: White crust layer on top soil at the time of sowing of Rabi crops

Photo 3.5: Measurement of the EC of water (OFR)

Source: Field Survey, 2013-14

The farmers who have access to canal irrigation water find that the salinity level of soil and water are within limit, and then they check the available water storage in existing nearby canals. After checking, if they find that the surface water is sufficient for applying around ten irrigations and if the farmers have access to capital for the production of Boro rice, then they decide to grow Boro rice (as shown in Photo 3.6). If they find that the water is not sufficient for growing Boro rice and they have access to capital for the production of sunflower, then they decide to grow sunflower (as shown in Photo 3.7). If the farmers have no access to capital for the production of Boro rice and sunflower and have access to capital for the production of sesame, then they decide to grow sesame (as shown in Photo 3.8). When the farmers have no access to capital for the production of Rabi crops, they keep the lands fallow.

On the other hand, the farmers who have access to on-farm reservoirs (OFR)/pond find that the salinity level in water is within limit, and then they assess the available water storage in existing OFR/pond. After assessing, if they find that the surface water is sufficient for applying around two or three irrigations and if the farmers have access to capital for the production of sunflower, then they decide to grow sunflower. When the farmers who have access to on-farm reservoir (OFR)/pond find that the salinity level in water is not within threshold limit, they keep the land fallow. If they find that the salinity level in water is within threshold limit but surface water is not sufficient for applying around two or three irrigations, then they check the residual moisture content in top soil. The farmers make the soil roll to check the residual moisture content in top soil. If the soil roll is broken then they can understand the residual moisture content in top soil. On the basis of farmers' information, the soil samples were collected and tested the soil moisture content. So, if the soils have average 10% (by weight) residual moisture content and the farmers have access to capital for the production of sesame, then it helps farmers to grow sesame, otherwise the farmers keep the land fallow. From the analysis of model, the EC > 12 dS/m in soil and EC > 11 dS/m in irrigation water were the main reasons of keeping the land fallow.

Photo 3.6: Boro rice field in Pankhali, Dacope, Khulna

Photo 3.7: Sunflower field in Pankhali, Dacope, Khulna

Photo 3.8: Sesame field in Pankhali, Dacope, Khulna

Source: Field Survey, 2013-14

4.2 Soil Salinity and Yield of Boro Rice and Rabi Crops as Practiced by the Farmers in Polder 31 (Cyclone Aila Non-Affected Area) and Polder 32 (Cyclone Aila Affected Area)

The Pankhali Union was the cyclone Aila non-affected area and included in Polder 31. The Kamarkhola Union was the cyclone Aila affected area and included in Polder 32. The EC of soil at vegetative stage, reproductive stage and ripening stage according to variety and the yield of Boro rice is shown in the Table 4.1.

Table 4.1: Comparison between EC of soil, variety and yield of Boro rice in Polder 31 and Polder 32

Name of the Union	Name of the location	Variety	EC (dS/m) of soil at vegetative stage (Jan 15- March 16)	EC (dS/m) of soil at reproductive stage (March 17- April 15)	EC (dS/m) of soil at ripening stage (April 16- May 15)	Threshold EC (dS/m) of soil	Yield (t/ha)
Pankhali (Polder 31)	Khona	BRRI Dhan-47	3.84	7.80	7.05	8.0	3.50
	Khatail	BRRI Dhan-47	3.50	6.92	6.46		3.00
	Lokmi khola	BRAC-5 (Shakti-2)	3.17	6.96	6.05	10.0	5.90
	Pankhali	BINA Dhan-8	3.81	7.09	6.72		4.00
	Pankhali	BRAC-5 (Shakti-2)	3.47	6.49	6.18		2.90
Average			3.50	7.05	6.49		
Kamar khola (Polder 32)	Channir chalk	BINA Dhan-8	3.80	6.79	8.70	10.0	4.00
	Shaha rabad	BINA Dhan-8	3.67	5.98	7.93		4.50
Average			3.74	6.38	8.31		

From the farmers practice, the average EC of soil at vegetative stage, reproductive stage and ripening stage was 3.50 dS/m, 7.05 dS/m and 6.49 dS/m respectively. The EC of soil was

3.84 dS/m at vegetative stage, 7.80 dS/m at reproductive stage and 7.05 dS/m at ripening stage for BRRI Dhan-47 in Khona village. The EC of soil was 3.50 dS/m at vegetative stage, 6.92 dS/m at reproductive stage and 6.46 dS/m at ripening stage for BRRI Dhan 47 in Khatail village. The yield of BRRI Dhan-47 was 3.50 t/ha in Khona and 3.00 t/ha in Khatail. In the BRRI practice the yield of BRRI Dhan-47 was 6.0 t/ha and the threshold EC of soil is 8 dS/m for BRRI Dhan-47 (Huq and Rabbani, 2011). The EC of soil was 3.17 dS/m at vegetative stage, 6.96 dS/m at reproductive stage and 6.05 dS/m at ripening stage for BRAC-5 (Shakti-2) in Lokmikhola village. The EC of soil was 3.47 dS/m at vegetative stage, 6.49 dS/m at reproductive stage and 6.18 dS/m at ripening stage for BRAC-5 (Shakti-2) in Pankhali village. The yield of BRAC-5 (Shakti-2) was 5.90 t/ha in Lokmikhola and 2.90 t/ha in Pankhali. The EC of soil was 3.81 dS/m at vegetative stage, 7.09 dS/m at reproductive stage and 6.72 dS/m at ripening stage for BINA Dhan-8 in Pankhali village. The yield of BINA Dhan-8 was 4.00 t/ha in Pankhali. In the BINA practice, the yield of BINA Dhan-8 was 5.5 t/ha under salt stresses (BINA, 2010). From the discussion with farmers, due to the severe pest attack, the yield was 2.90 t/ha for the Hybrid variety of Boro rice BRAC-5 (Shakti-2) in Pankhali village. In the BRAC practice, the yield of Hybrid variety of Boro rice, Shakti-2 (BRAC-5) was 7.6 t/ha (Rashid et al., 2011). In spite of applying pesticides, the farmers could not get the desired yield of Shakti-2 (BRAC-5). The threshold EC of soil is 10 dS/m for BINA Dhan-8 (BINA, 2010). The threshold EC of soil is 10 dS/m for Shakti-2 (Rashid et al., 2011)

The EC of soil varied from the vegetative stage to ripening stage for the all Boro rice variety. The EC of soil decreased at ripening stage than reproductive stage. From the analysis of rainfall, it was found the amount of rainfall was 33 mm at ripening stage and 5 mm at reproductive stage. There was the variation of yield according to the variety. The highest yield was 4.8 t/ha for the variety of BINA Dhan-8. In spite of having the EC of soil at tolerant level the yield decreased. From the discussion with farmers, the farmers applied more fertilizer than recommended level. The excess fertilizer increased the vegetative growth of rice, hampered the reproductive growth of rice and ultimately decreased the yields. In the study area, most of the farmers selected the Hybrid variety of Boro rice Shakti-2 (BRAC-5). Because of the NGO motivated the farmers by training and supplying the seeds.

The farmers of both Channirchalk and Shaharabad village cultivated the BINA Dhan-8. The DAE motivated the farmers to cultivate BINA Dhan-8 in Polder 32. The BINA Dhan-8 variety is more salt tolerant than BRRI Dhan-47. The Polder 32 was cyclone Aila affected area and more saline than Polder 31.The EC of soil was 3.80 dS/m at vegetative stage, 6.79 dS/m at reproductive stage and 8.70 dS/m at ripening stage in Channirchalk village. The EC of soil was 3.67 dS/m at vegetative stage, 5.98 dS/m at reproductive stage and 7.93 dS/m at ripening stage in Shaharabad village. The yield of BINA Dhan-8 in Channirchalk and Shaharabad was 4.00 t/ha and 4.5 t/ha respectively. The average EC of soil was 3.74 dS/m at vegetative stage, 6.38 dS/m at reproductive stage and 8.31 dS/m at ripening stage. From the analysis of rainfall, it was found the amount of rainfall was 33 mm at ripening stage and 5 mm at reproductive stage. In spite of having salinity at tolerant level the yield decreased because the farmers did not follow the recommended fertilizer.

The EC of soil was high at vegetative, reproductive and ripening stage in Polder 32 than Polder 31. In spite of having same amount of rainfall both in Polder 31 and Polder 32, the EC of soil increased at ripening stage in Polder 32 than Polder 31.

The maximum farmers cultivated the local variety of sesame. Because of the seed of local variety of sesame was available in the local market. A few of farmers cultivated the BARI Til 4. Since, they got the seed of BARI Til-4 from DAE as an experimental plot. The EC of soil was 4.1 dS/m at vegetative stage, 8.04 dS/m at reproductive stage and 6.85 dS/m at ripening stage in Khatail village. The EC of soil was 3.93 dS/m at vegetative stage, 8.03 dS/m at reproductive stage and 5.56 dS/m at ripening stage in Khona village. The EC of soil was 3.61 dS/m at vegetative stage, 7.36 dS/m at reproductive stage and 6.88 dS/m at ripening stage in Lokmikhola village. The average EC of soil was 3.88 dS/m at vegetative stage, 7.81 dS/m at reproductive stage and 6.43 dS/m at ripening stage. A few of farmers cultivated the sesame in Polder 32. The EC of soil was 4.13 dS/m at vegetative stage, 8.21dS/m at reproductive stage and 6.36 dS/m at ripening stage in Kamarkhola village of Polder 32.

The EC of soil varied from vegetative stage to ripening stage for the local variety of sesame. The EC of soil decreased at ripening stage than reproductive stage. The EC of soil at vegetative stage, reproductive stage and ripening stage of sesame and the yield of sesame are shown in the Table 4.2.

From the analysis of rainfall, it was found the amount of rainfall was 33 mm at ripening stage and 5 mm at reproductive stage. In Khatail, Khona and Lokmikhola, the yield was 0.80 t/ha, 0.71 t/ha and 0.75 t/ha respectively. In BARI practice, the yield of sesame was 1.3 t/ha. From the discussion with farmers, the farmers did not apply irrigation due to lack of irrigation water. Also, the farmers applied less fertilizer than BARI recommended practice. So, the yield decreased due to the lack of irrigation water and proper nutrition.

Table 4.2: Comparison between EC of soil, variety and yield of sesame (variety: local) in Polder 31 and Polder 32

Name of the Union	Name of the location	EC (dS/m) of soil at vegetative stage (Feb 20-March 30)	EC (dS/m) of soil at reproductive stage (March 31-April 30)	EC (dS/m) of soil at ripening stage (May 01 - May 20)	Threshold EC (dS/m) of soil	Yield (t/ha)
Pankhali (Polder 31)	Khatail	4.1	8.04	6.85	6.0	0.80
	Khona	3.93	8.03	5.56		0.71
	Lokmikhola	3.61	7.36	6.88		0.75
Average		3.88	7.81	6.43		
Kamarkhola (Polder 32)	Kamarkhola	4.13	8.21	6.36		0.60

The EC of soil at vegetative stage, pre-flowering stage and heading stage of sunflower and the yield of sunflower are shown in the Table 4.3. From the farmers practice, the EC of soil was 2.22 dS/m at vegetative stage, 4.36 dS/m at pre-flowering stage and 6.53 dS/m at heading stage in Khatail village. The EC of soil was 2.62 dS/m at vegetative stage, 4.77 dS/m at pre-flowering stage and 6.94 dS/m at heading stage in Khona village. The EC of soil was 2.65 dS/m at vegetative stage, 4.82 dS/m at pre-flowering stage and 7.01 dS/m at heading stage in Lokmikhola village. The EC of soil was 2.34 dS/m at vegetative stage, 4.80 dS/m at pre-flowering stage and 6.90 dS/m at heading stage in Kamarkhola village. The average EC of soil was 2.50 dS/m at vegetative stage, 4.65 dS/m at pre-flowering stage and 6.82 dS/m at heading stage. Most of the farmers cultivated the Hysun-33 variety of sunflower. The seed of the Hysun-33 variety was supplied by the BRAC. A few of farmers cultivated the sunflower in Polder 32. The EC of soil was 2.34 dS/m at vegetative stage, 4.80 dS/m at pre-flowering stage and 6.90 dS/m at heading stage in Kamarkhola village of Polder 32. The threshold EC of soil is 6.0 dS/m (SRDI, 2014) for sesame.

Table 4.3: Comparison between EC of soil, variety and yield of sunflower (variety: Hysun-33) in Polder 31 and Polder 32

Name of the Union	Name of the location	EC (dS/m) of soil at vegetative stage (Jan 20 – Feb 20)	EC (dS/m) of soil at pre-flowering stage (Feb 21 – Mar 22)	EC (dS/m) of soil at heading stage (Mar 23 – April 21)	Threshold EC (dS/m) of soil	Yield (t/ha)
Pankhali (Polder 31)	Khatail	2.22	4.36	6.53	4.8	1.7
	Khona	2.62	4.77	6.94		0.7
	Lokmikhola	2.65	4.82	7.01		1.3
Average		2.50	4.65	6.82		
Kamarkhola (Polder 32)	Kamarkhola	2.34	4.80	6.90		0.8

From the analysis of rainfall, it was found the amount of rainfall was 24 mm at flowering stage and 5 mm at heading stage. So, the EC of soil increased at heading stage than flowering stage. In Khatail, Khona, Lokmikhola and Kamarkhola village, the yield was 1.7 t/ha, 0.7 t/ha, 1.3 t/ha and 0.8 t/ha respectively. The potential yield of sunflower was 2 t/ha (according to BRAC). The farmers got the lower yield than the previous years because they applied less fertilizer than BARI recommended doses. The threshold EC of soil is 4.8 dS/m (FAO, 2001) for sunflower.

4.3 Intensity of Water Salinity in the Sources of Irrigation Water in Different Locations of Polder 31 and Polder 32

From the discussion with farmers, the canal/Khal and OFR/pond water of cyclone Aila affected area is more saline than cyclone Aila non-affected area. The sources of irrigation water for the irrigated crops (Boro rice and sunflower) and the level of water salinity in different locations of Polder 31 and Polder 32 is shown in the Table 4.4.

From the analysis of field measurements, the EC of the water was 17.11 dS/m (May) in a canal of cyclone Aila affected area (Polder 32) and 9.00 dS/m (May) in a canal of cyclone

Aila non-affected area (Polder 31). The EC of Vhadra River was also high in different months. The farmer did not use these sources of irrigation water.

Table 4.4: Comparison between EC of water in canal/Khal, on farm reservoir (OFR)/ pond, river and sources of irrigation water for the irrigated crops (Boro rice and sunflower) in Polder 31 and Polder 32

Location of the water body	Name of the village	Source of the water	EC (dS/m) of water (29 Jan)	EC (dS/m) of water (20 Feb)	EC (dS/m) of water (20March)	EC (dS/m) of water (30 April)	EC (dS/m) of water (20 May)
Polder 31	Pankhali	canal/Khal	11.1	12.18	14.04	14.7	9.0
Polder 32	Kamarkhola	canal/Khal	21.10	23.16	26.69	27.95	17.11
Polder 31	Lokmikhola	OFR	0.8	1.20	1.70	1.90	1.80
Polder 32	Kamarkhola	pond	2.90	4.43	6.27	7.01	2.95
Polder 32	Kamarkhola	Vhadra river	8.16	9.96	11.45	13.54	13.94
Polder 31	Khatail	canal/Khal	0.9	2.4	2.81	3.01	1.90
Polder 31	Pankhali	canal/Khal	1.38	1.50	1.76	2.02	2.61

One of the canals of cyclone Aila non-affected areas was used as a source of irrigation water. The EC of that canal water was 0.9 dS/m in January, 2.4 dS/m in February, 2.81 dS/m in March, 3.01 dS/m in April and 1.90 dS/m in May. The name of the canal was Pankhali Khal and located in Pankhali Union. The farmers of Pankhali village used this canal water to irrigate Boro rice during Rabi season. The EC of pond water in cyclone Aila affected area was 2.90 dS/m in January, 4.43 dS/m in February, 6.27 dS/m in March, 7.01 dS/m in April and 2.95 dS/m in May. The farmers of cyclone Aila affected area did not use pond water for applying irrigation water. They did not construct any OFR to conserve water. They were not interested to construct the OFR. So, some of the farmers did not cultivate the sunflower. The OFR in cyclone Aila non-affected area was used for growing sunflower. The EC of OFR in that area was 0.80 dS/m in January, 1.20 dS/m in February, 1.70 dS/m in March, 1.90 dS/m in April and 1.80 dS/m in May. From the analysis of rainfall, it was found the amount of rainfall varied in different months and the intensity of EC of water was also varied in the respective months.

The source of irrigation water was important to the farmers. The surface water was the only source of irrigation water in the Dacope Upazila of Khulna district. The canal/Khal, on farm reservoir (OFR) and pond were used as a source of surface irrigation water (as shown in Photo 3.9, 3.10 and 3.11).

Photo 3.9: On farm reservoir (OFR) besides sunflower field

Photo 3.10: Source of irrigation water (canal) for Boro rice cultivation

Photo 3.11: Source of irrigation water (pond) for sunflower cultivation

Source: Field Survey, 2013-14

The farmer who had access to canal irrigation water cultivated the Boro rice. The farmer who had no facility of canal irrigation water, they used OFR and pond water to cultivate sunflower. The farmers who had no any kind of irrigation facility cultivated sesame. From the Table 4.4, in Pankhali Moddopara block, there were two canals named Hatkhola and Pankhali. Due to high salinity the Hatkhola Khal water was not used for irrigation. The water of Pankhali Khal was used for applying irrigation water. The Pankhali Khal was the source of irrigation for cultivating Hybrid variety of Boro rice (BRAC-5) local named Shakti-2. The Katakhali canal located Khatail was the source of irrigation water for the cultivation of BRRI Dhan-47.The Kewratoli canal located Kamarkhola was the source of irrigation water for cultivation of BINA Dhan-8. The OFR and pond was the source of irrigation water for the cultivation of sunflower.

4.4 Irrigation Scheduling for the Irrigated Crops (Boro Rice and Sunflower) in Polder 31 and Polder 32

From the discussion with farmers, the farmers applied AWD method for the cultivation of Boro rice. The number, amount, timing of irrigation water and yield of the irrigated crops is shown in the Table 4.5. Some of the farmers applied irrigation at 6 days interval and some farmers applied irrigation at 7 days interval. The number of irrigations varied from 14 to 17 in Polder 31. Some of the farmers used AWD pipe to measure when irrigation should be applied. Other did not use any AWD pipe and applied irrigation by the traditional method. So, the number of irrigation varied from one farmer to another farmer. For BRRI Dhan-47, in Khatail and Khona the seasonal amount of irrigation water was 909 mm and 1062 mm respectively and yield was 3.00 t/ha and 3.50 t/ha respectively.

For Hybrid variety of Boro rice, Shakti-2 (BRAC-5), in Lokmikhola village, the farmer applied 1083 mm irrigation water and yield was 5.90 t/ha. The exceptional case in Pankhali village, for a Hybrid variety of Boro rice, Shakti-2 (BRAC-5), in spite of applying 949 mm irrigation water the yield was 2.90 t/ha because of the excessive pest attack. For BINA Dhan-8, in Pankhali village, the farmer applied 1005 mm irrigation water and yield was 4.00 t/ha. The calculated seasonal irrigation water requirement (IWR) was 1336 mm (Appendix-D). The water requirement for the land preparation (LP) in the study area was considered as 200 mm. The following yield versus amount of irrigation water relationship (as shown in Figure 4.2) was obtained from the analysis of Table 4.5.

Table 4.5: Relationship between amount of irrigation water and yield of Boro rice in Polder 31 and Polder 32

Name of the Union	Name of the location	Variety	The number of irrigation water	The timing of irrigation water	Seasonal amount of irrigation water (farmers' practice) (mm)	Yield (t/ha)
Pankhali	Khona	BRRI Dhan-47	17	6 days interval	1062	3.50
	Khatail	BRRI Dhan-47	14	7 days interval	909	3.00
	Lokmikhola	BRAC-5 (Shakti-2)	17	6 days interval	1083	5.90
	Pankhali	BINA Dhan-8	16	6 days interval	1005	4.00
	Pankhali	BRAC-5 (Shakti-2)	15	7 days interval	949	2.90
Suterkhali	Channir chalk	BINA Dhan-8	10	7 days interval	678	4.00
	Shaharabad	BINA Dhan-8	23	4 days interval	1187	4.50

In Polder 32, most of the farmers selected BINA Dhan-8 due to high salt tolerant. In Channirchalk and Shaharabad the farmer applied the 678 mm and 1187 mm irrigation water and yield was 4.00 t/ha and 4.50 t/ha and the number of irrigation water was 10 and 23 respectively. It is obtained from the Figure 4.2 that the variation of yield for Boro rice was not only depended on amount of irrigation water but also on the soil salinity, water salinity and fertilizer dose.

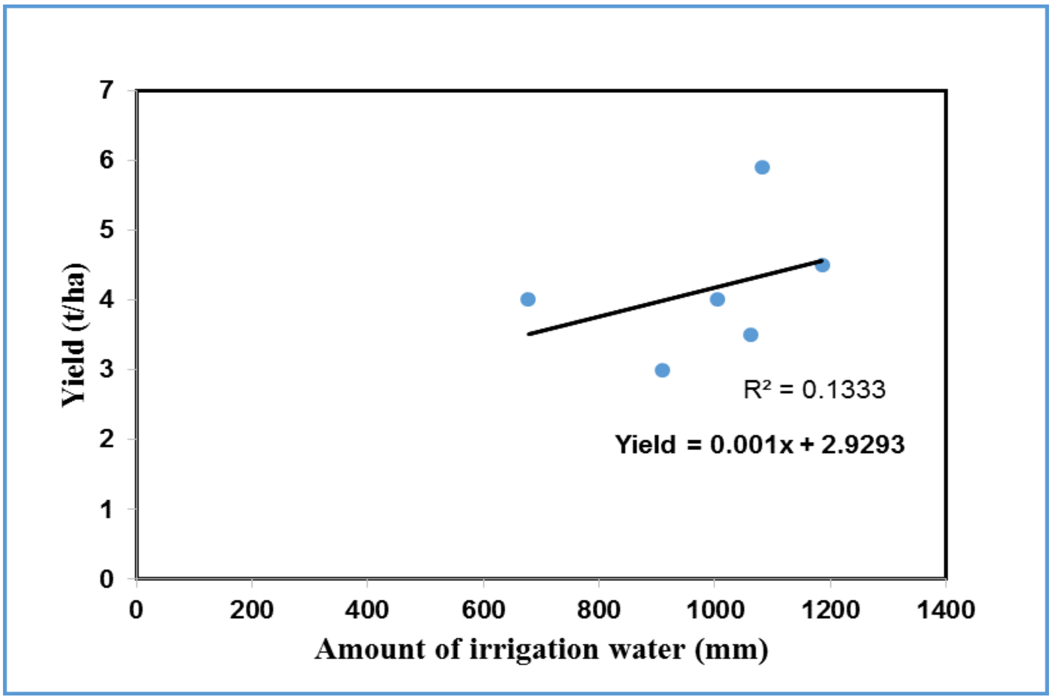


Figure 4.2: Yield of Boro rice as function of amount of irrigation water

The number, amount, timing and yield of sunflower are shown in the Table 4.6. From the discussion with farmers, most of the farmers cultivated the Hysun-33 variety of sunflower. But they did not use the same amount of irrigation water. Some of the farmers applied two irrigations and some applied three irrigations. As the amount of water available in domestic pond was not sufficient and the farmers require this water for household works, they did not apply third irrigation. In Khatail, the farmer applied 273 mm irrigation water with two irrigations and got the yield 1.5 t/ha. In another village Khona, the farmer applied 164.39 mm irrigation water with two irrigations and got the yield 0.7 t/ha.

The farmer of Khatail applied the first irrigation after 15 days of seedling and the farmer of Khona applied the first irrigation after 30 days of seedling. On the other hand, in Lokmikhola the farmer applied 225 mm irrigation water with three numbers of irrigations and got the yield 1.3 t/ha. In Kamarkhola, the farmer applied 135 mm irrigation water with two irrigations and got the yield 0.6 t/ha. In Kamarkhola Moddopara, the farmer applied 180 mm irrigation water with two irrigations and got the yield 0.8 t/ha. In BARI practice, for the BARI Surjomukhi-2 the used water was 183 mm with deficit irrigation and the yield was 2.5 t/ha in Satkhira district. The calculated field irrigation water requirement (IWR) of sunflower was 308 mm (Appendix-D). The following yield versus amount of irrigation water relationship (as shown in Figure 4.3) was obtained from the analysis of Table 4.6.

Table 4.6: Relationship between amount of irrigation water and yield of sunflower in Polder 31 and Polder 32

Name of the Union	Name of the location	Variety	The number of irrigation water	The timing of irrigation water	Amount of irrigation water (farmers' practice) (mm)	Yield (t/ha)
Pankhali (Polder 31)	Khatail	Sunflower (Hysun-33)	2	1st and 2nd irrigation = after 15 and 60 days of seedling respectively	273	1.7
	Khona	Sunflower (Hysun-33)	2	1st and 2nd irrigation = after 30 and 60 days of seedling respectively	164	0.7
	Lokmikhola	Sunflower (Hysun-33)	3	1st, 2nd and 3rd irrigation = after 15, 30 and 45 days of seedling respectively	225	1.3
Kamarkhola (Polder 32)	Kamarkhola	Sunflower (Hysun-33)	2	1st and 2nd irrigation = after 15 and 30 days of seedling respectively	135	0.6
	Kamarkhola Moddopara	Sunflower (Hysun-33)	2	1st and 2nd irrigation = after 30 and 60 days of seedling respectively	180	0.8

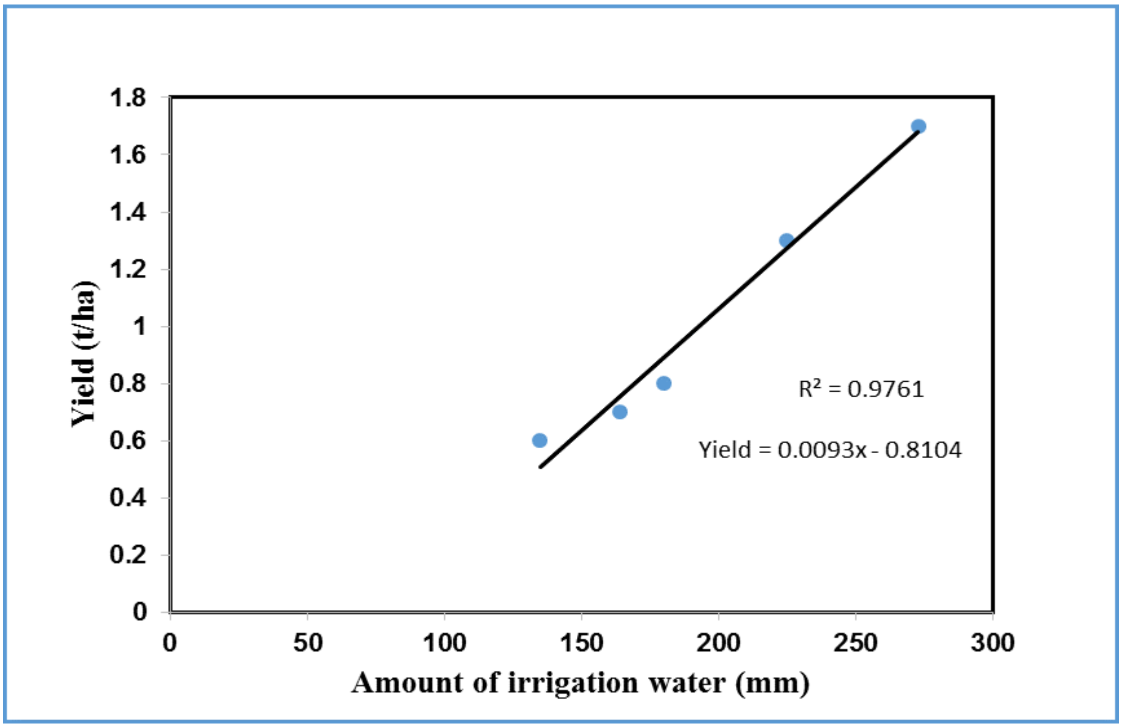


Figure 4.3: Yield of sunflower as function of amount of irrigation water

4.5 Profitability

The benefit-cost ratio (BCR) of growing BINA Dhan-8, BRRI Dhan-47, Shakti-2 (BRAC-5), sunflower (Hysun-33) and sesame (local) as per farmers' practice is shown in Table 4.7, 4.8, 4.9, 4.10 and 4.11 respectively.

4.5.1 Survey on Input Use, Yield and Profitability at Farmers' Level

A survey of Boro rice, sunflower and sesame farmers in the study area was conducted in order to assess their yields, input uses, profitability, knowledge about water and fertilizer management practices.

A survey of Boro rice (BINA Dhan-8) in farmers practice to assess the benefit-cost ratio (BCR) is shown in the Table 4.7. The yield of BINA Dhan-8 was about 4.0 t/ha. The total cost of production was 33818 Tk. /ha in which irrigation cost was 10636 Tk. /ha (about 31%).

Table 4.7: Benefit-cost ratio of Boro rice (BINA Dhan-8) in farmers practice

Items		BINA Dhan-8	
		Amount/ 0.22 ha	Tk. /ha
Seeds		15 kg (@40 Tk./kg)	2727
Fertilizers	Urea	58 kg (@ 16 Tk./ kg)	4218
	TSP	26 kg (@ 22 Tk./ kg)	2600
	MOP	32kg (@ 15 Tk./ kg)	2182
	Zn	2 kg (@ 200 Tk./ kg)	1818
Pesticide application cost	Pesticide	Tk.130	591
	labor	Tk.100	455
Land preparation		Tk. 1000	4545
Irrigation cost		58.5 hour, (@ 40 Tk./ hr)	10636
Harvesting		Tk.350	1591
Threshing		Tk.450	2045
Transportation cost		Tk.90	410
Total cost of production		Tk.7440	33818
Rice production		880 kg (@16.5Tk/ kg)	66000
Gross return		Tk. 14520	66000
Net return		Tk. 7080	32182
Benefit-cost ratio(Farmer)		-	1.95
Rice yield			4.0 t/ha

Source: Field Survey, 2013-2014

A survey of Boro rice (BRRI Dhan-47) in farmers practice to assess the benefit-cost ratio (BCR) is shown in the Table 4.8. In the farmers practice, the average benefit-cost ratio (BCR) of BRRI Dhan-47 was 1.53.

Table 4.8: Benefit-cost ratio of Boro rice (BRRI Dhan-47) in farmers practice

Items		BRRI Dhan-47	
		Amount/ 0.22 ha	Tk. /ha
Seeds		15 kg (@40 Tk./kg)	2727
Fertilizers	Urea	58 kg (@ 16 Tk./ kg)	4218
	TSP	26 kg (@ 22 Tk./ kg)	2600
	MOP	32kg (@ 15 Tk./ kg)	2182
	Zn	2 kg (@ 200 Tk./ kg)	1818
Pesticide application cost	Pesticide	Tk.130	591
	labor	Tk.100	455
Land preparation		Tk. 1000	4545
Irrigation cost		50.0 hour, (@ 40 Tk./ hr)	9091
Harvesting		Tk.350	1591
Threshing		Tk.450	2045
Transportation cost		Tk.90	410
Total cost of production		Tk.7100	32273
Rice production		660 kg (@16.5Tk/ kg)	49500
Gross return		Tk. 10890	49500
Net return		Tk. 3790	17227
Benefit-cost ratio(Farmer)		-	1.53
Rice yield			3.0 t/ha

Source: Field Survey, 2013-2014

The yield of BRRI Dhan-47 was about 3.0 t/ha. The total cost of production was 32273 Tk. /ha in which irrigation cost was 9091 Tk. /ha (about 28%).

A survey of Boro rice (Shakti-2) in farmers practice to assess the benefit-cost ratio (BCR) is shown in the Table 4.9. In the farmers practice, the average benefit-cost ratio (BCR) of Shakti-2 was 2.01.

Table 4.9: Benefit-cost ratio of Boro rice (Shakti-2) in farmers practice

Items		Shakti-2	
		Amount/ 0.34ha	Tk. /ha
Seeds		6 kg (@300 Tk./kg)	5294
Fertilizers	Urea	91 kg (@ 16 Tk./ kg)	4282
	TSP	40 kg (@ 22 Tk./ kg)	2588
	MOP	50 kg (@ 15 Tk./ kg)	2206
	Zn	3 kg (@ 200 Tk./ kg)	1765
Pesticide application cost	Pesticide	Tk.640	1882
	labor	Tk.350	1029
Land preparation		Tk. 1000	4545
Irrigation cost		80 hour, (@ 40 Tk./ hr)	27682
Harvesting		Tk.1350	3970
Threshing		Tk.1250	3676
Transportation cost		Tk.500	1471
Total cost of production		Tk.13776	40518
Rice production		1680 kg (@16.5Tk/ kg)	81529
Gross return		Tk. 27720	81529
Net return		Tk. 13944	41012
Benefit-cost ratio(Farmer)		-	2.01
Rice yield			5.9 t/ha

Source: Field Survey, 2013-2014

The yield of Shakti-2 was about 5.90 t/ha. The total cost of production was 40518 Tk. /ha in which irrigation cost was 27682 Tk. /ha (about 68 %).

A survey of sunflower (Hysun-33) in farmers practice to assess the benefit-cost ratio (BCR) is shown in the Table 4.10. From the farmers' survey, the average benefit-cost ratio (BCR) of sunflower was 2.2.

Table 4.10: Benefit-cost ratio of sunflower (Hysun-33) in farmers practice

Items		Variety: Hysun-33	
		Amount/ 0.24 ha	Tk. /ha
Seeds		1.2 kg (@1200 Tk./kg)	6000
Fertilizers	Urea	30 kg (@ 16Tk./ kg)	2000
	TSP	20 kg (@ 22Tk./Kg)	1833
	MOP	20kg (@ 15Tk./ kg)	1250
	Gypsum	20 kg (@ 8 Tk./kg)	667
Pesticide application cost	Pesticide	Tk.250	1042
	labor	2(@300 Tk./labor)	2500
Land preparation		Tk. 1782	7425
Irrigation cost		3(@ 400 Tk./irrigation)	5000
Harvesting cost (labor)		2(@300 Tk./labor)	2500
Threshing cost (labor)		3(@300 Tk./labor)	3750
Transportation cost		Tk.200	833
Total cost of production		Tk.8352	34800
Sunflower Production		408 kg (@ 32Tk/ kg)	54400
Gross return		Tk. 13056	54400
Net return		Tk. 4704	19600
Benefit-cost ratio (Farmer)		-	1.56
Sunflower yield			1.7 t/ha

Source: Field Survey, 2013-2014

The yield of sunflower was about 1.7 t/ha. The total cost of production was 34800 Tk. /ha in which irrigation cost was 5000 Tk. /ha (about 14.37%). The main reasons for cultivating sunflower (Hysun-33) were soil salinity, lack of fresh water and the presence of the OFR and pond water.

A survey of sesame (local) in farmers practice to assess the benefit-cost ratio (BCR) is shown in the Table 4.11. From the farmers' survey, the average benefit-cost ratio (BCR) of sesame was 1.3.

Table 4.11: Benefit-cost ratio of sesame (local) in farmers practice

Items		Variety: sesame	
		Amount/ 0.13 ha	Tk. /ha
Seeds		1 kg (@ 55Tk./kg)	417
Fertilizers	Urea	10 kg (@ 16 Tk./kg)	1212
	TSP	10 kg(@ 22 Tk./kg)	220
	MOP	3 kg(@ 15 Tk./kg)	341
	Zypsum	7 kg (@ 8 Tk./kg)	424
Pesticide application cost	Pesticide	Tk. 150	1136
	Labor	2 (@ 300 Tk./labor)	4545
Land preparation		Tk.1400	10606
Irrigation cost		-	-
Harvesting (labor cost)		2 (@ 300 Tk./labor)	4545
Threshing (labor cost)		4 (@ 300 Tk./labor)	9091
Transportation cost		Tk. 100	758
Total cost of production		4586	34742
Sesame production		105.6 kg (@ 60Tk/ kg)	48000
Gross return		Tk. 6336	48000
Net return		Tk. 1750	13258
Benefit-cost ratio (Farmer)		-	1.3
Sesame yield			0.8 t/ha

Source: Field Survey, 2013-2014

The yield of sesame was about 0.8 t/ha. The total cost of production was 34742 Tk. /ha. The farmers did not apply any irrigation for the sesame production. So, there was no irrigation cost of sesame. The main reason for cultivating sesame was no source of irrigation water.

The farmer's inputs and BRRI recommended inputs of Boro rice is shown in the Table 4.12.

Table 4.12: Comparison between farmer's inputs and BRRI recommended inputs of Boro rice

Name of crops	Inputs Name	Fertilizer recommendation, Kg/ ha	Farmers' practice, Kg/ha
BRRI Dhan-47	TSP	98	120
	MOP	68	146
	Zn	12	10
	Urea	190	264
	Gypsum	60	30
	Irrigation	AWD method	6 days interval
	Yield	6.0 t/ha	3.0 t/ha

The farmers applied more fertilizer to cultivate Boro rice because they did not have appropriate knowledge, information and training about the recommendation level from DAE and other NGOs.

The farmer's inputs and BARI recommended inputs of sunflower and sesame are shown in the Table 4.13. From the farmers' survey, the farmers' applied fertilizer for cultivating sunflower (Hysun-33) and sesame (local) but did not follow the BARI recommended inputs. They applied less fertilizer than recommended inputs. It was the wrong idea of farmers in applying fertilizer dose. The farmers did not know how much fertilizer should be applied. They did not follow the irrigation scheduling. The farmers did not apply any irrigation for cultivating sesame.

Table 4.13 Comparison between farmer's inputs and BARI recommended inputs of sunflower and sesame

Name of crops	Inputs Name	BARI recommendation Kg/ ha	Farmers' practice Kg/ha
Sunflower	Urea	190	161.25
	TSP	170	90.00
	MP	160	45
	Gypsum	160	35
	Zinc sulfate	9	-
	Boric acid	11	-
	Magnesium sulfate	90	-
	Cow dung	9	-
	Irrigation	First irrigation at 25-30 days of seedling and second irrigation at 45-50 days of seedling	1st irrigation at 15-30 days of seedling and 2nd irrigation at 60 days of seedling
	Yield	2.15 t/ha	1.7 t/ha
Sesame	Urea	112.5	75.76
	TSP	140	75.76
	MP	45	22.73
	Gypsum	105	53.03
	Zinc sulfate	5	-
	Boric acid	10	-
	Irrigation	First irrigation at 25-30 days of seedling and second irrigation at 55-60 days of seedling	-
	Yield	1.3 t/ha	0.8 t/ha

4.6 The Development of Farmers Livelihood Security Indicators in Polder 31 and Polder 32

A conceptual crop decision model for coastal farmers has been developed depending on some indicators, as tools to assess the impacts of crop selection on the livelihood of farmers. So it was needed to describe an approach for the identification of suitable indicators, by linking with the crop selection and livelihood security of the selected crop farmers in the relevant area.

Development of livelihood security indicators has been performed through the specific understanding of the cropping pattern, irrigation water management and profitability in cyclone Aila affected (Polder 32) and non-affected (Polder 31) area. The information of a season from sowing to harvesting of crops of the specific area has been considered for profitability assessment of the Boro rice, sunflower and sesame crop producing farmer in coastal area of Bangladesh. Farmer's livelihood security indicators have been formed as the functional unit of the crop producing farmers in coastal area. The farmers' livelihood security indicators have been developed based on areas in which they live, observed living status, their individual access to irrigation water, irrigation water facility, their knowledge and training to begin Rabi season. The soil salinity, water salinity, salt tolerant Rabi crops, irrigation water requirement of Rabi crops, profitability of Rabi crops have been major concern in indicator development. Primary and secondary information has been used to form the link between decision model and livelihood security indicator for Polder 31 and Polder 32. A set of indicators of crop farmers' indicators (shown in the Table 4.14) has been formed based on simple form of DFID framework and primary information from general field observation of the selected coastal area.

The selected DFID framework indicators are the simply form according to the definition of DFID framework. All indicators were normalized to have a relative position between 0 and 1. Focus Group Discussion (FGD) of crop producing farmers in the study area was conducted in order to develop farmers livelihood security index (FLSI). According to the DFID livelihood asset model, each livelihood group has five types of assets – (i) Natural assets, (ii) Financial assets, (iii) Human assets, (iv) Physical assets, and (v) Social assets (Islam, 2004). In Polder 32 and Polder 31, during focus group discussions, farmers were asked to highlight indicators linked to each form of asset (i.e. Human, financial, natural, physical and social assets).

Table 4.14: The selecting criteria of DFID framework indicators for developing the crop farmers' indicators

Assets	DFID framework indicators	Crop farmers' indicators
Social	Networks and connectedness, access to wider institutions of society	Access to soil information, availability of effective extension services, availability of new varieties and availability of fertilizer and pesticides in the market.
Human	Skills, knowledge, ability, education/training personnel	Training of the farmers and motivation of the farmers.
Natural	Land, forests, marine/wild resources, water	Canal irrigation water and OFR/pond irrigation water.
Financial	Availability of cash or equivalent, productivity	Profit and yield
Physical	Infrastructure, access to water supply	Irrigation water facility, amount of irrigation water, and access to marketing network.

Assumption: The DFID framework has been followed for the development of crop farmers' indicators. But all indicators of the DFID framework were not considered. The simply indicators has been considered because only crop producing farmers' livelihood has been selected in the study area. The developed crop farmers' indicators are the representative of all indicators of DFID framework.

Actually indicators have been developed by the secondary and primary information related to the crop selection. Indicators for the security of coastal crop farmers' livelihoods have been identified from different dimensions of livelihood capitals. Each indicator has been defined depending on specific reason. It has been tried to show relative, reliable, representative and logical cause behind each one. The questions were posed during data collection to obtain information on the indicators. The background criteria were also observed during collecting this data (shown in the Table 4.15).

Table 4.15: Indicators of farmers' livelihood security index collected through FGD across crop producing farmers in Polder 31 and Polder 32

Com-ponent	Indicators	Questions posed during data collection to obtain information on this indicator	Challenges and solutions with collecting this data as experienced in the field/ Background criteria
Social assets	Access to soil information	Do you have access to soil information for your agricultural activities during Rabi (dry) season?	The problem related to farmers who had no knowledge of soil salinity level. In such cases, the farmers kept fallow land.
	Availability of effective extension services	Do you get extension services from Agriculture Office?	This was a fairly straightforward question.
	Availability of new varieties, fertilizer and pesticides in the market?	Do you get salt tolerant varieties of Rabi crops, fertilizer and pesticides in the market?	The problem related to farmers in Polder 32.
Human assets	Training of the farmers	Do you have any scope of training related to crop selection from Govt., NGO etc.?	Generally, the farmers had little scope of training related to crop selection.
	Motivation of the farmers	Are you motivated in Rabi crop selection by any organization?	The farmers were motivated by demonstration plot in Rabi crop selection.
Natural assets	Canal irrigation water	Do you have access of canal irrigation water?	The farmers who had no access to the canal, they did not select Boro rice during Rabi (dry) season.
	OFR/pond irrigation water	Do you have any OFR or pond water to irrigate your crop field?	The farmers who had an alternate source (OFR/pond) of irrigation water, they selected Rabi non- rice (sunflower) crops.

Financial assets	Profit	From which crop you get highest profit?	The farmers who got the highest yield from Boro rice, they were not satisfied with the Rabi rice yield. Considering the production cost and market price, the farmers got the benefit from sesame.
	Yield	From which crop you get highest yield?	The farmers got the highest yield from Boro rice Shakti-2 (BRAC-5), and then got the lowest yield from sesame.
Physical assets	Irrigation water facility	Is there sufficient water for ten irrigations in canal and two or three irrigations in OFR/pond?	The farmers, who had sufficient water storage facility for ten irrigations, selected Rabi rice crop. The farmers who had an alternate source of irrigation water, selected sunflower crop. Otherwise, the farmers selected sesame.
		Do you have the infrastructure and irrigated equipment facility?	There were leakages in the gate and many farmers had no own pump for the application of irrigation water in Polder 32.
	Amount of irrigation water	Which crop requires more irrigation water?	The rice required maximum amount of irrigation water. Then sunflower required one third irrigation water. The farmers did not require any irrigation for sesame.
	Access to marketing network	Do you have access to marketing network?	The farmers of Polder 32 did not sell sunflower and sesame. The road network was not easy to market. The wholesaler came to the Polder 32 and the farmers sold the Boro rice.

Source: Field Survey 2013-2014

4.6.1 Farmers Livelihood Security Weight Value for Crop Producing Farmers in Polder 31 and Polder 32

Based on the local farmers the weighing and ranking of indicators are shown in the Table 4.16 in Polder 31. According to field survey, the indicators have been developed and the importance of the indicators has been cited. The farmers of Polder 31 give the importance to yield of crops than profit where the farmers of Polder 32 give importance to profit of crops than yield. The Polder 32 is far away from the market place. The access to marketing network is good in Polder 31. So, the farmers of Polder 31 give importance to yield than profit. The social assets are comprised of availability of new varieties, fertilizer and pesticides in the market, an effective extension services and access to soil information. The indicators of human assets are training and motivation of the farmers. The training improves the agricultural knowledge of farmers. When the farmers motivated by someone, then they become interested to take a new challenge in an adverse situation. In Polder 32, the farmer was motivated to grow BINA Dhan-8 but in Polder 31, Shakti-2 Boro rice. When the farmers get the training then they can know about the new variety, salt tolerant variety of crops. The extension service is helpful for the farmers to the production of crops.

The canal irrigation water and OFR/pond irrigation water is the important natural asset both in Polder 31 and Polder 32. The farmers in Polder 32 are not interested to construct OFR. So, unavailability of OFR is the main problem in Polder 32 for the sunflower cultivation. The profit and yield from the crop are the indicators of financial assets. In Polder 31 the profit and yield has cited 9 and 11 times as most important where as in Polder 32 has cited 15 and 10 times as most important respectively. It can be explained that the farmers in Polder 31 give emphasis on good yield than Polder 32. On the other hand, the farmers in Polder 32 give emphasis on good profit than Polder 31.

Access to marketing network, Irrigation water facility and amount of irrigation water are the indicators of physical assets both in Polder 31 and Polder 32. From the Table 4.15 and 4.16, it can be explained that access to marketing network is the main problem to the farmers in Polder 32 whereas irrigation water facility is the main problem in Polder 31. Since, the insufficient storage capacity in the canals of Polder 31 for the Boro rice cultivation.

Table 4.16: Weighting system based on local farmers (Boro rice, sunflower and sesame producing farmers) in Polder 31(Cyclone Aila non-affected area)

Component	Indicator	Times cited as most important	Relative Importance	Weighing (Indicators %)	Rank	Weighing (Components %)
Social assets	Access to soil information	4	5.80	6	8	15
	Availability of effective extension services	3	4.35	4	11	
	Availability of new varieties in the market	2	2.89	3	12	
	Availability of fertilizer and pesticides in the market	1	1.58	2	13	
Human assets	Training of the farmers	5	7.25	7	7	13
	Motivation of the farmers	4	5.80	6	9	
Natural assets	Canal irrigation water	8	11.60	12	3	19
	OFR/pond irrigation water	5	7.25	7	6	
Financial assets	Profit	9	13.34	13	2	29
	Yield	11	15.82	16	1	
Physical assets	Access to marketing network	4	5.80	6	10	24
	Irrigation water facility	6	8.40	8	5	
	Amount of irrigation water	7	10.12	10	4	
	Total	69	100.00	100		100

Source: Field Survey 2013-2014

Based on the local farmers the weighing and ranking of indicators are shown in the Table 4.17 in Polder 32.

Table 4.17 weighting system based on local farmers (Boro rice, sunflower and sesame producing farmers) in Polder 32 (cyclone Aila affected area)

Component	Indicators	Times cited as most important	Relative Importance	Weighing (Indicators %)	Rank	Weighing (Components %)
Social assets	Access to soil information	8	8.50	9	5	22
	An effective extension services	3	3.66	4	12	
	Availability of new varieties in the market	2	2.17	2	13	
	Availability of fertilizer and pesticides in the market	6	6.52	7	7	
Human assets	Training of the farmers	4	4.35	4	11	9
	Motivation of the farmers	5	5.43	5	9	
Natural assets	Canal irrigation water	14	15.22	15	2	23
	OFR/pond irrigation water	7	7.60	8	6	
Financial assets	Profit	15	16.30	16	1	27
	Yield	10	10.67	11	3	
Physical assets	Access to marketing network	9	9.78	10	4	19
	Irrigation water facility	4	4.35	4	10	
	Amount of irrigation water	5	5.44	5	8	
	Total	92	100.00	100		100

Source: Field Survey 2013-2014

4.6.2 Farmers Livelihood Security Standard Value for Crop Producing Farmers in Polder 31 and Polder 32

The farmers' livelihood security standard has been defined from the standard value of all livelihood security indicators. The standard values have been shown by collecting data of actual value (Appendix-E) through a local FGD (Focus Group Discussion) in Polder 31 and Polder 32. The standardized value of sub-index for Boro rice, sunflower and sesame producing farmers in Polder 31 is shown in the Table 4.18 (calculated in the Appendix- F).

Table 4.18 Farmers livelihood security standard value of crop producing farmers in Polder 31

Assets	Indicators	Standardized value of sub-index for Boro rice producing farmers	Standardized value of sub-index for sunflower producing farmers	Standardized value of sub-index for sesame producing farmers
Social	Access to soil information	0.03	0.03	0.04
	Availability of effective extension services	0.04	0.04	0.01
	Availability of new varieties in the market	0.01	0.02	0.02
	Availability of fertilizer and pesticides in the market	0.01	0.01	0.01
Human	Training of the farmers	0.04	0.05	0.05
	Motivation of the farmers	0.06	0.06	0.03
Natural	Canal irrigation water	0.12	0.00	0.00
	OFR/Pond, irrigation water	0.07	0.04	0.00
Financial	Profit	0.03	0.07	0.13
	Yield	0.16	0.04	0.08
Physical	Access to marketing network	0.06	0.06	0.06
	Irrigation water facility	0.09	0.05	0.00
	Amount of irrigation water	0.10	0.10	0.00

Source: Field Survey 2013-2014

The standardized value for individual indicators (calculated in the Appendix- F) was developed by using the local farmers' opinion in Polder 31 and Polder 32. All indicators were normalized to have a relative position between 0 and 1 (equation 9). Finally, those values were calculated from the combined data of FGDs.

The standardized value of sub-index for Boro rice, sunflower and sesame producing farmers in Polder 32 is shown in the Table 4.19 (calculated in the Appendix- F).

Table 4.19 Farmers livelihood security standard value of crop producing farmers in Polder 32

Assets	Indicators	Standardized value of sub-index for Boro rice producing farmers	Standardized value of sub-index for sunflower producing farmers	Standardized value of sub-index for sesame producing farmers
Social	Access to soil information	0.05	0.06	0.06
	Availability of effective extension services	0.01	0.02	0.03
	Availability of new varieties in the market	0.01	0.01	0.01
	Availability of fertilizer and pesticides in the market	0.07	0.05	0.04
Human	Training of the farmers	0.03	0.02	0.03
	Motivation of the farmers	0.04	0.02	0.02
Natural	Canal irrigation water	0.08	0.00	0.00
	OFR/pond irrigation water	0.05	0.05	0.00
Financial	Profit	0.12	0.08	0.16
	Yield	0.11	0.05	0.06
Physical	Access to marketing network	0.07	0.00	0.00
	Irrigation water facility	0.04	0.04	0.00
	Amount of irrigation water	0.05	0.01	0.00

Source: Field Survey 2013-2014

When the farmers find any problem to grow crops due to travelling cost they are not interested to go in the agriculture office for the desired suggestion. In Polder 31, the maximum farmers cultivate the Shakti-2 Boro rice, Hysun-33 sunflower, local sesame due to availability in the market. If they get effective service from DAE about the EC of soil salinity and new variety, they could choose the right salt tolerant variety. Training and motivation is perceived as an important human asset. The most of the farmers are influenced by the other farmer activities.

The significant differences of the standardized value of sub-index are found in case of natural, financial and physical assets (Table 4.18 and 4.19). It can be explained that canal irrigation water is an important asset to the Boro rice producing farmers. When the farmers have the facility to use the canal as a source of irrigation water grow the Boro rice. For this, the amount of irrigation water is also related to the Boro rice. When the water storage is sufficient in the canal/Khal to apply about ten irrigations then the farmers grow the Boro rice. After that the capital cost is another factor to grow Boro rice, sunflower and sesame. In Polder 31, the Boro rice, sunflower and sesame producing farmers have access to marketing network but different in Polder 32. The wholesaler comes to buy only for Boro rice in Polder 32. The social, human, natural, financial and physical assets value of Boro rice, sunflower and sesame producing farmers in Polder 31 are shown in the Table 4.20. The calculation procedure of the obtained values of Table 4.20 is shown in Appendix-F.

Table 4.20 Comparison of each asset of the crop producing farmers in Polder 31 (cyclone Aila non-affected area)

Assets	Boro rice	Sunflower	Sesame
Social	0.09	0.10	0.08
Human	0.11	0.11	0.08
Natural	0.19	0.04	0.00
Financial	0.19	0.15	0.15
Physical	0.25	0.21	0.06

Source: Field Survey 2013-2014

The social asset value of Boro rice, sunflower and sesame producing farmers were almost near. From the human assets analysis, the sesame producing farmers did not scope of training. Since, there was no source of irrigation water and irrigation water facility the natural and physical asset value of sesame producing farmers were zero. From the farmers' point of view, the financial asset value of sesame producing farmers were 0.15, sunflower producing farmers were 0.15 and Boro rice producing farmers were 0.19.

The social, human, natural, financial and physical assets value of Boro rice, sunflower and sesame producing farmers in Polder 32 are shown in the Table 4.21 (calculated in the Appendix- F).

Table 4.21 Comparison of each asset of the crop producing farmers in Polder 32 (cyclone Aila affected area)

Assets	Boro rice	Sunflower	Sesame
Social	0.14	0.13	0.13
Human	0.06	0.04	0.05
Natural	0.13	0.05	0.00
Financial	0.15	0.13	0.14
Physical	0.16	0.05	0.00

Source: Field Survey 2013-2014

From the farmers' point of view, the financial asset value of Boro rice producing farmers was 0.15, sunflower producing farmers was 0.13 and sesame producing farmers was 0.14. The physical asset value of Boro rice producing farmers was 0.16, sunflower producing farmers was 0.05 and sesame producing farmers was 0.00. The Boro rice producing farmers was better irrigation facility than sunflower and sesame. The canal was the source of irrigation water for growing Boro rice. After Aila, the farmers are not interested to construct OFR in Polder 32. They were always dependent to the govt. and private organizations. The wholesaler did not come to buy sunflower and sesame seeds. They came to buy Boro rice. So, the sunflower was not cultivated more than Boro rice. It can be explained for the financial assets of both Polder, the farmers of Polder 32 cultivated the BINA Dhan-8. The EC of soil was high in Polder 32 than Polder 31. The farmers of Polder 31 cultivated the BINA Dhan-8, BRRI Dhan-47 and Shakti-2. They got the better yield and profit from the BINA Dhan-8 and Shakti-2 where as in Polder 32 from the BINA Dhan-8.

4.6.3 The Individual Security of an Asset by the Area of Pentagon

The areas of livelihood assets of the crop producing farmers in Polder 31 and Polder 32 are shown in the Figure 4.4 and Figure 4.5 respectively (calculated in the Appendix-G).

From the comparative analysis of Figure 4.4 and Figure 4.5, the livelihood assets area of Boro rice occupy the more area than sunflower and sesame whereas sunflower occupy the more area than sesame. It is clear that the overall livelihood of Boro rice producing farmers is better than sunflower and sesame producing farmers. Again the livelihood of sunflower producing farmers is better than sesame producing farmers.

From the Figure 4.4 and 4.5, both in Polder 31 and Polder 32, the noticeable change is found in case of the area of physical assets and natural assets. It is a sign of better opportunity being to the farmers of Boro rice producing farmers. They have the opportunity to use canal as a source of irrigation water, to go market easily for buying and selling. In Polder 32, it is not easy to go market for this purpose.

The sunflower producing farmers have the opportunity of OFR irrigation water whereas do not have the canal irrigation water. The sesame producing farmers do not have any kind of irrigation water facility. There is more saline problem in Polder 32 and the yield difference is found in case of sunflower and sesame. Based on the tolerance level and variety, the better yield found from BINA Dhan-8 in Polder 32 whereas Shakti-2 in Polder 31.

The livelihood of sesame producing farmers both in Polder 31 and Polder 32 is near about close. Since both have the common problem of irrigation water. The livelihood of sunflower producing farmers in Polder 31 is better than in Polder 32 because availability of more OFR gives more opportunity to cultivate the sunflower; comparatively less saline problem gives the more profit and yield.

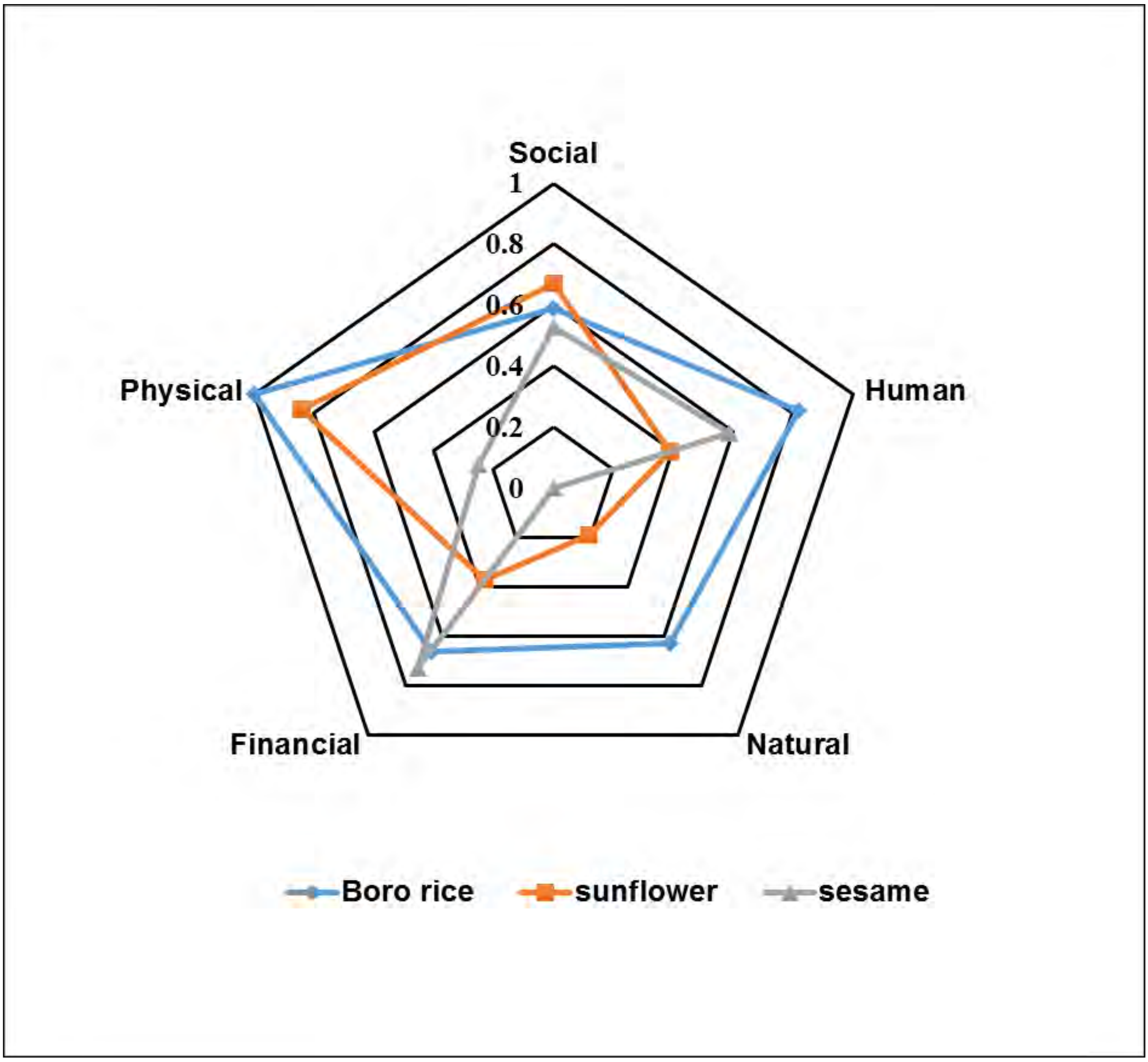


Figure 4.4: The pentagon illustrating the five components of livelihood assets of the crop producing farmers in Polder 31

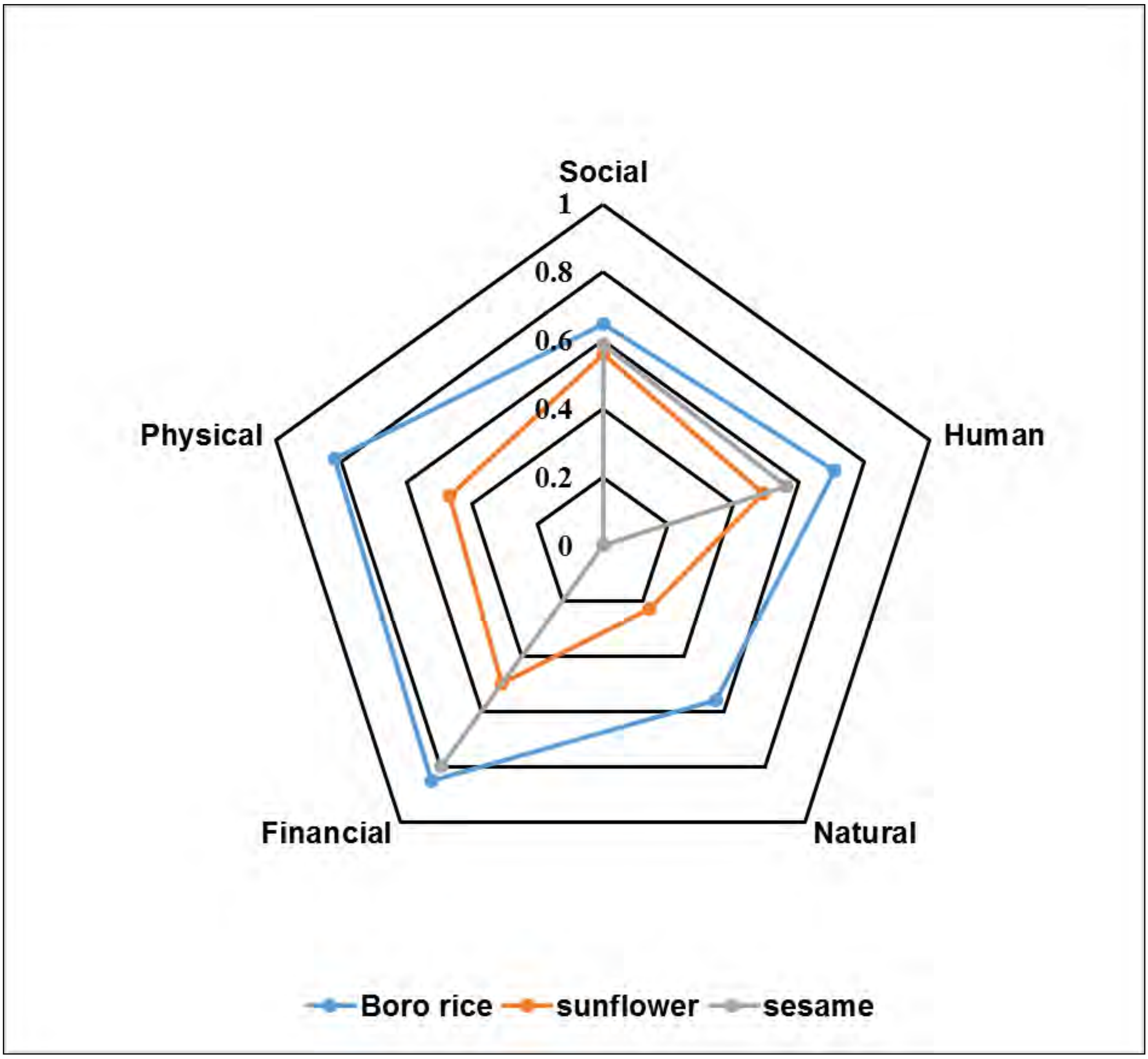


Figure 4.5: The pentagon illustrating the five components of livelihood assets of the crop producing farmers in Polder 32

4.6.4 Farmers Livelihood Security Index (FLSI) of Boro Rice, Sunflower and Sesame Producing Farmers in Polder 31 and Polder 32

The Farmers' Livelihood Security Index (FLSI) of Boro rice, sunflower and sesame crop producing farmer was calculated using equation (10) for both Polders. The FLSI values of Boro rice, sunflower and sesame producing farmers are shown in the Table 4.22 (calculated in the Appendix-G).

Table 4.22 Comparison of livelihood security among Boro rice, sunflower and sesame producing farmers

Name of the crop producing farmer	FLSI (Polder 31)	FLSI (Polder 32)
Boro rice	0.83	0.64
Sunflower	0.61	0.41
Sesame	0.37	0.32

The higher the index value indicates the higher security. From the index value analysis, the livelihood of Boro rice producing farmers was secured compared to sunflower and sesame producing farmers. The sunflower producing farmers' livelihood was secured compared to sesame producing farmers. On the other side, in case of Polder 31, the FLSI value of Boro rice, sunflower and sesame producing farmers was 0.83, 0.61 and 0.37 respectively. In case of Polder 32, the FLSI value of Boro rice, sunflower and sesame producing farmers was 0.64, 0.41 and 0.32 respectively. From the analysis, the livelihood of farmers in cyclone Aila non-affected area (Polder 31) was more secured compared to the livelihood of farmers in the cyclone Aila affected area (Polder 32). The different index value, it can be explained that the EC of both soil and water in Polder 32 is more than Polder 31. So, the farmers get better profit and yield to Boro rice than sunflower and sesame. The farmers get more effective extension service, more knowledge about the soil salinity, more training in Polder 31. The marketing network, amount of irrigation water and irrigation water facilitates give the secured farmers' livelihood in Polder 31. So, canal leads to the better irrigation water facility and storage capacity for the cultivation of Boro rice. The OFR/pond leads to the cultivation of sunflower. The absence of irrigation water leads to the cultivation of sesame.

4.7 The Discussion between the Farmers' Crop Selection and Livelihood Assets

The indicators of natural, financial and physical assets affect the farmers' crop selection. Among the social assets, access to soil information also affects the farmers' crop selection. Since the presence of soil salinity at the time of sowing Rabi crops the farmers keep the land fallow. When the farmers will have to the knowledge of soil and water salinity level and training, they will select the right salt tolerant variety to grow crops. The training will be helpful to motivate the farmers. Then the indigenous knowledge about the fertilizer dose for the cultivation of Boro rice, sunflower and sesame will be changed by the training. When the farmers will have, the more canals and more water storage in the canal, they will cultivate the more Boro rice crops with the canal irrigation water. They will get the more profit and yield. The farmers' livelihood will be more secure by the cultivation of Boro rice in both polders. The sunflower and sesame producing farmers will change their decision. They will select the Boro rice instead of sunflower and sesame. In these ways, the indicators of social, human, natural, financial and physical assets will change the decision pathway of the farmers.

Chapter Five

Conclusions and Recommendations

5.1 Conclusions

The conclusions drawn from this study are summarized below.

1) Six factors, namely, EC of soil at the time of sowing of Rabi crops, source of irrigation water, EC of irrigation water in existing canals/OFR/pond, amount of irrigation water, soil moisture content and access to capital determine the farmers' decision regarding selection of Rabi crops. Some farmers do not cultivate any crops due to the presence of soil salinity in top soil, lack of fresh surface water for irrigation, lack of residual moisture content and lack of capital for the production of crops in the Rabi season and keep their land fallow.

2) If the farmers find that the level of soil salinity is below 12 dS/m, have access to canal irrigation water, the level of water salinity is below 11 dS/m, have sufficient water storage for about ten irrigations in existing canals, have access to capital cost for the production of Boro rice, then they decide to grow Boro rice. When the farmers have access to on-farm reservoirs (OFR)/pond irrigation with water storage for about two or three irrigations and have capital for the production of sunflower, then they decide to grow sunflower. When the farmers have no source of irrigation water and have capital, then they decide to grow sesame with residual moisture content.

3) The seasonal amount of irrigation water use by Boro rice as practiced by the farmers was about 1000mm but the calculated seasonal irrigation water requirement (IWR) was about 1336 mm. The yields of BRRI Dhan-47, BRAC-5 (Shakti-2) and BINA Dhan-8 under farmers' practice were 3.00 t/ha, 5.90 t/ha and 4.00 t/ha, respectively. The BCR of growing BRRI Dhan-47, BRAC-5 (Shakti-2), and BINA Dhan-8 were 1.53, 2.01, and 1.95 respectively. The average EC (dS/m) of soil at vegetative, reproductive and ripening stages were 3.56 dS/m, 7.05 dS/m and 6.49 dS/m in Polder 31 and 3.73 dS/m, 6.38 dS/m and 8.30 dS/m in Polder 32 respectively. The livelihood security level was 83% in Polder 31 and 64% in Polder 32.

4) The amount of irrigation water use by sunflower as practiced by the farmers was about 220 mm and the calculated irrigation water requirement (IWR) was about 308 mm. The yield of sunflower (Hysun-33) under farmers' practice was 1.3 t/ha. The BCR of growing sunflower was 1.56. The average EC (dS/m) of soil at vegetative, flowering and heading stages were 2.49 dS/m, 4.65 dS/m and 6.82 dS/m, respectively. The livelihood security level was 61% in Polder 31 and 41% in Polder 32.

5) The sesame was cultivated by the farmers with 10% residual moisture content. The yield of sesame (local) under farmers' practice was about 0.7t/ha. The BCR of growing sesame (local) was 1.30. The livelihood security level was 37% in Polder 31 and 32% in Polder 32.

6) The farmers used canal, OFR and pond as a source of irrigation water. The source of irrigation water and amount of irrigation water strongly influenced the farmers' decision regarding the selection of crop.

7) The measured security index values of farmers' livelihoods for producing Boro rice, sunflower and sesame show different level of security both in Polder 31 and Polder 32. The security levels of farmers' livelihood vary with source of irrigation water, irrigation water facility, farmers' access to soil information, access to marketing network, training and motivation of farmers, availability of new varieties, availability of fertilizer and pesticides and effective extension services. For Boro rice producing farmers the highest livelihood security level is 83% in Polder 31where as for sesame producing farmers is 32% in Polder 32.

5.2 Recommendations

Based on the findings of the study, the following recommendations can be made.

- DAE should take the necessary steps to make the farmers aware of the number, timing and amount of irrigation application and fertilizer use for Rabi season crops.
- More canal and OFR/pond would go a long way in cultivating Boro rice, sunflower and sesame.
- This study was conducted in only two polders in one coastal district, which is inadequate to represent the overall scenario of coastal farmers.
- Besides crop, aquaculture consideration would generalize in the coastal area.

APPENDIX-A

A Checklist for Individual Interview and Focus Group Discussion

১) কেন পতিত রাখেন?

২) কিভাবে বুঝেন মাটিতে লবনাক্ততা বেশি?

৩) কিভাবে বুঝেন পানিতে লবনাক্ততা বেশি?

৪) যদি বুঝেন পানির লবনাক্ততা বেশি তাহলে কি করেন? অন্য কোন বিকল্প পানির উৎস আছে নাকি সেচ পানি ব্যবহারের?

৫) কিভাবে বুঝেন মাটিতে রস আছে কিনা?

৬) মাটির রস কম হলে কেন ফসল করা যাবে না?

৭) সঞ্চিত পানির পরিমাণ কিভাবে বুঝেন?

৮) কোন ফসল করতে কতটুকু পানি থাকা দরকার খালে, পুকুরে বা জমির পাশে গর্তে সেটা কিভাবে বুঝেন?

৯) কোন ফসলের জন্য কোন উৎস থেকে সেচ দেন?

১০)বোর ধানে কতদিন পর পর সেচ দেন?

১১)সূর্যমুখীতে ২টা বা ৩টা সেচ দিচ্ছেন কেন? ৩টা দিচ্ছেন না কেন? যারা ২টা দেয় তারা কেন দেয়?

১২)তিলে সেচ দিচ্ছেন না কেন?

১৩)খরচ কোন ফসলে বেশী? বোর ধানে নাকি সূর্যমুখীতে নাকি তিলে?

১৪)কোন ফসলের ফলন ভালো?

১৫)কোন ফসলের দাম ভালো পান?

Source: Field Survey, 2013-14

APPENDIX-B

The Location Map of FGD and List of Participants in Polder 31 and Polder 32

In each Polder (Polder 31 and Polder 32) nine FGD's were conducted with the farmers. The location map of the FGD is shown in Figure 1.

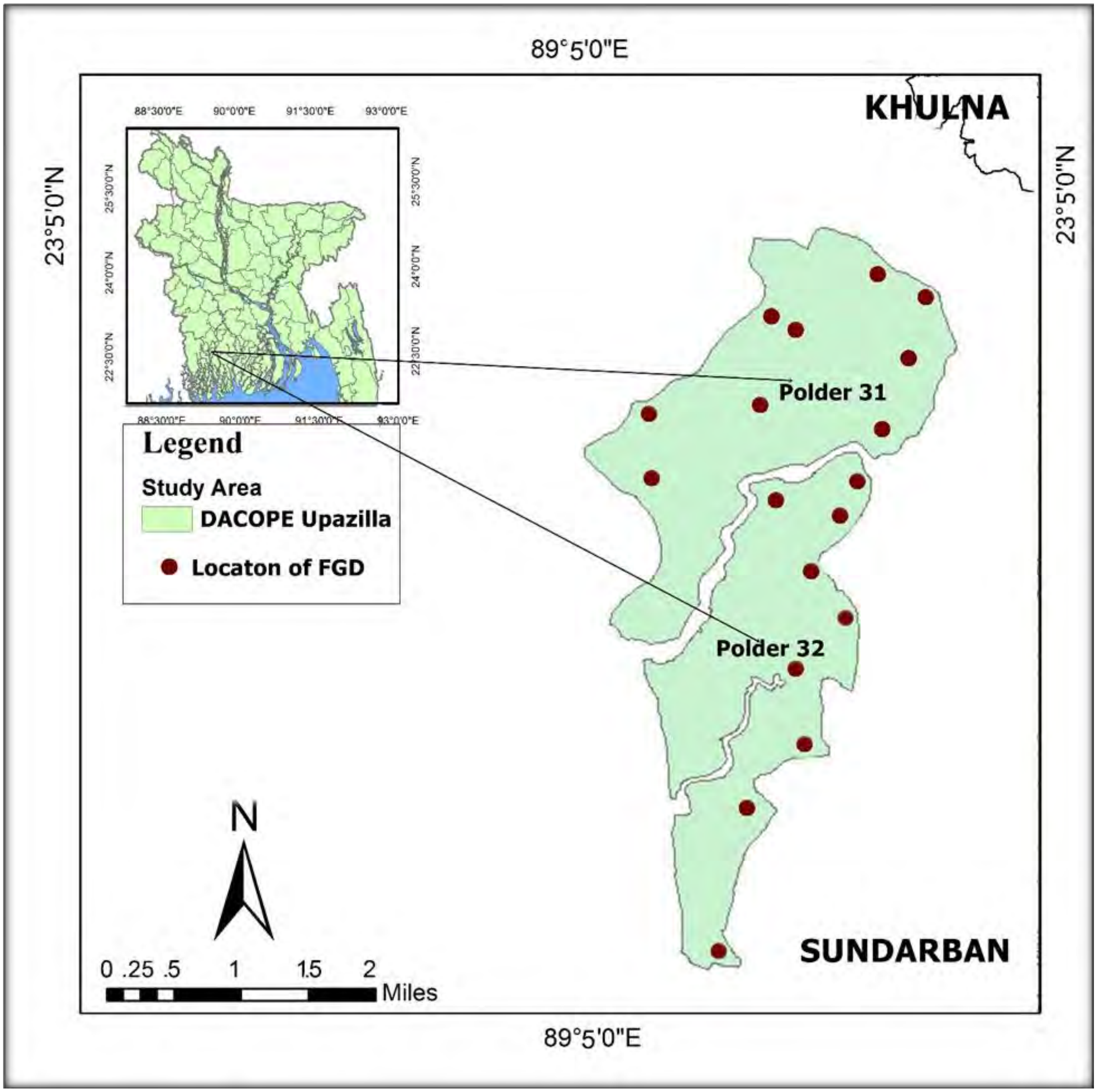


Figure 1: Location of the FGD in southwestern coastal region of Bangladesh

Name of the Location	Date	Time
Pankhali	29.01.2014	12.00 pm
Khona	21.02.2014	12.00 pm
Khatail	21.02.2014	02.00 pm
Lokmikhola	22.02.2014	11.00 am
Channirchalk	22.02.2014	02.00 pm
Shaharabad	17.05.2014	01.00 pm
Chalna	17.05.2014	03.00 pm
Tildanga	18.05.2014	10.30 am
Sutarkhali	18.05.2014	01.00 pm
Kamarkhola	13.05.2015	12.00 pm
Sreenagar	13.05.2015	02.30 pm
Kalinagar	14.05.2015	10.00 am
Nalian	14.05.2015	03.00 pm

List of Participants (Crop Farmers') During FGD in the Study Area:

Sl. No.	Name of the Farmers	Sl. No.	Name of the Farmers
1	Md. Abdur Rashid Gazi	31	Topon Mondal
2	Indrajeet Ray	32	Ronjeet Mondal
3	Afsar Sarder	33	Bijlee Mondal
4	Mahmud	34	Sandha Ghorami
5	Dibakar Golder	35	Kali Mondal
6	Purnendu Shekhor Boiragi	36	Bandana Mondal
7	Binaykrishno Mondal	37	Oshima Mondal
8	Vhobesh Torofdar	38	Inda Mondal
9	Gobindo Sarker	39	Bolita Ghorami
10	Mannan Sheikh	40	Horen Ray
11	Proshanto Bala	41	Taposh Chandro Ray
12	Kumaresh Sarker	42	Nazrul Islam
13	Topon Baher	43	Nironjan Sarder
14	Proshanto Sarker	44	Litu Fakir
15	Md.Muhsin Sarder	45	Madon Mondal
16	Md.Shahabuddin Sarker	46	KrishnoVordu Sarker
17	Alok Sarker	47	Shoshdhar Mondal
18	Usha Ray	48	Animesh Bayen
19	Billal Saha	49	Piyashee Gayen
20	Abdul Hadi Sheikh	50	Mahbub Sheikh
21	Abdul Halim	51	Abdur Rafiq Sheikh
22	Mahfuzur Rahman	52	Amimur Gazi
23	Sannashi Mondal	53	Anando Gayen
24	Bisshojeet Mondal	54	Krishnopodo Bachar
25	Sheikh Babul Akhter	55	Jogobondhu Ray
26	Lalita Mondal	56	Jotendronat Mondal
27	Kumaresh Dhara	57	Zaglul Karim
28	Poshupoti Ray	58	Suvash Mondal
29	Ochinta Ray	69	Nasima
30	Prokash Ray	60	Moyen Gazi

Sl. No.	Name of the Farmers	Sl. No.	Name of the Farmers
61	Mojibur Rahman	90	Porimal Bepari
62	Mannan Bepari	91	Amir Dewan
63	Abul Kalam	92	Md. Korban Ali
64	Anil Datto	93	Md. Ishak Miah
65	Hanif Sheikh	94	Md. Tajul Sarker
66	Biplob Hawlader	95	Hossen Jaman
67	Barek Sarder	96	Lutfor Rahman
68	Abul Kalam Khan	97	Jagodish Sheikh
69	Shantu Bepari	98	Hashem Mollah
70	Faruq Hossen	99	Sirajul Haque
71	Shahin Mallik	100	Shafiullah
72	Md. Borhan Uddin	101	Mojibor Dhali
73	Kalimollah Sikder	102	Shadon Paul
74	Mukter Hossen	103	Sheikh Mokshed
75	Bacchu Sheikh	104	Khalil Sheikh
76	Afaj Uddin Sheikh	105	Sayed Mahmud
77	Mofi Sheikh	106	Motaleb Fokir
78	Shelina Morol	107	Yakub Hai
79	Jibon Dash	108	Mannan Jomir
80	Manek De	109	Mujit Paul
81	Md. Shamsul Sarder	110	Md. Shamim Molla
82	Md. Ranjeet Sarker	111	Montu Vawer
83	Abdul Hakim Mridha	112	Nitto Nando
84	Md. Jahangir Sheikh	113	Md. Jakir Hossen
85	Alauddin Madbar	114	Hiron Khondoker
86	Md. Tota Miah	115	Alim Uddin
87	Md. Sumon Sheikh	116	Sheikh Abbash
88	Md. Aminur Sheikh	117	Md. Yunush Hawlader
89	Ali Akber	118	Md. Salam Baher
Sl. No.	Name of the Farmers	Sl. No.	Name of the Farmers
119	Nasir Khan	141	Md. Monir

120	Masum Sheikh	142	Md. Anower Hossen
121	Pobitra Mondal	143	Kaium Hawlader
122	Sumitra Mondal	144	Kashem
123	Hafizur Rahman	145	Roman Sheikh
124	Nurul Amin Sheikh	146	Joinal Hawlader
125	Shamsul Huda Munshi	147	Md. Shahjahan Morol
126	Ahsan Kabir Khan	148	Juesna
127	Shahidul Islam	149	Harunur Rashid
128	Mannan Sikder	150	Mohammad Ali
129	Nurul Islam	151	Md. Billal Hossen
130	Bashir Khan	152	Shamol Miah
131	Jalal Uddin	153	Mahfuz Miah
132	Lal Miah	154	Md. Abu Hanif
133	Md. Shahid Sarder	155	Shah Ali Akber
134	Alamgir Karim	156	Md. Borhan Uddin
135	Rabi Morol	157	Aman Ullah
136	Abdul Hai	158	Mukter Hossen
137	Hanif Madbor	159	Khadem Ali
138	Pran Krishna	160	Chan Miah Dewan
139	S. M. Rasel	161	Abul Kalam
140	Hamed Khan		

APPENDIX-C

The Decision Pathway with Case Studies for the Selection of Boro rice, Sunflower and Sesame Crops

The decision pathway for the selection of Boro rice is shown in the Figure 2

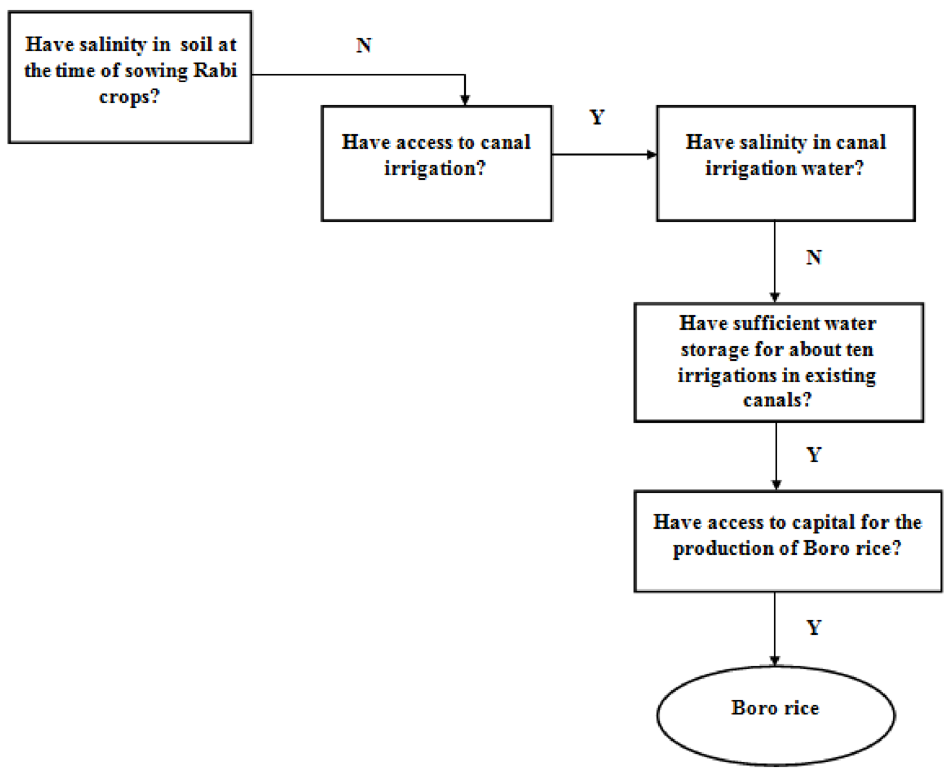


Figure 2: Farmers' decision pathway for the selection of Boro rice in coastal area

Case 1 – Selection of Boro Dhan as a Rabi crop in Pankhali Union (31 Polder): Mannan Shekh, aged 40

Born to this union, cyclone Aila did not affect the 31 Polder. Seven years ago, the Mannan Shekh started to cultivate Boro Dhan in the Rabi season. The farmer did not find the white crust layer in soil at the time of starting Rabi crops. The farmer observed the growth of trees and homestead vegetables. In the previous (2012-2013) Rabi season, the farmer cultivated the both rice (Boro rice) and non-rice (sunflower and sesame) but got the highest yield and profit for Boro Dhan than sunflower and sesame. The farmer used the canal water to irrigate Boro Dhan. The farmers used the water of Pankhola Khal (Canal). The canal water was not saline because the farmer used the water of that canal for homestead vegetables. There was sufficient storage to apply irrigation water. The farmer had the capital to bear the production and irrigation cost of Boro rice. The farmer selected the hybrid variety of Boro Dhan (BRAC variety) named Shakti 2. Suddenly the farmer got the unexpected yield 2.9 t/ha in the 2013-2014 Rabi season. He found the pest attack, severe than the previous year. He applied the pesticide, but got the minor result. During 2012-2013 Rabi season, the farmer got the yield 5.0 t/ha but during 2013-2014 Rabi season, he got the yield 2.9 t/ha.

Case 2 – Selection of Boro Dhan as a Rabi crop in Pankhali Union (31 Polder): Sonnashi Mondal, aged 34

Sonnashi Mondal decided to cultivate Boro Dhan. The farmer got around 5.5 t/ha yields of Aman Dhan and made an idea that the soil was moderately saline. She was under a block and there were 36 members in the block. From the discussion with members, she noted that 'they have a source of fresh irrigation water in the canal and they follow the neighborhood'. The neighbors got the best yield from Boro Dhan. The canal water was sufficient for applying irrigation water in the Boro rice field. The farmer had the capital to bear the irrigation cost of Boro rice. So, the farmer selected Boro rice as a Rabi crop.

The decision pathway for the selection of sunflower is shown in the Figure 3

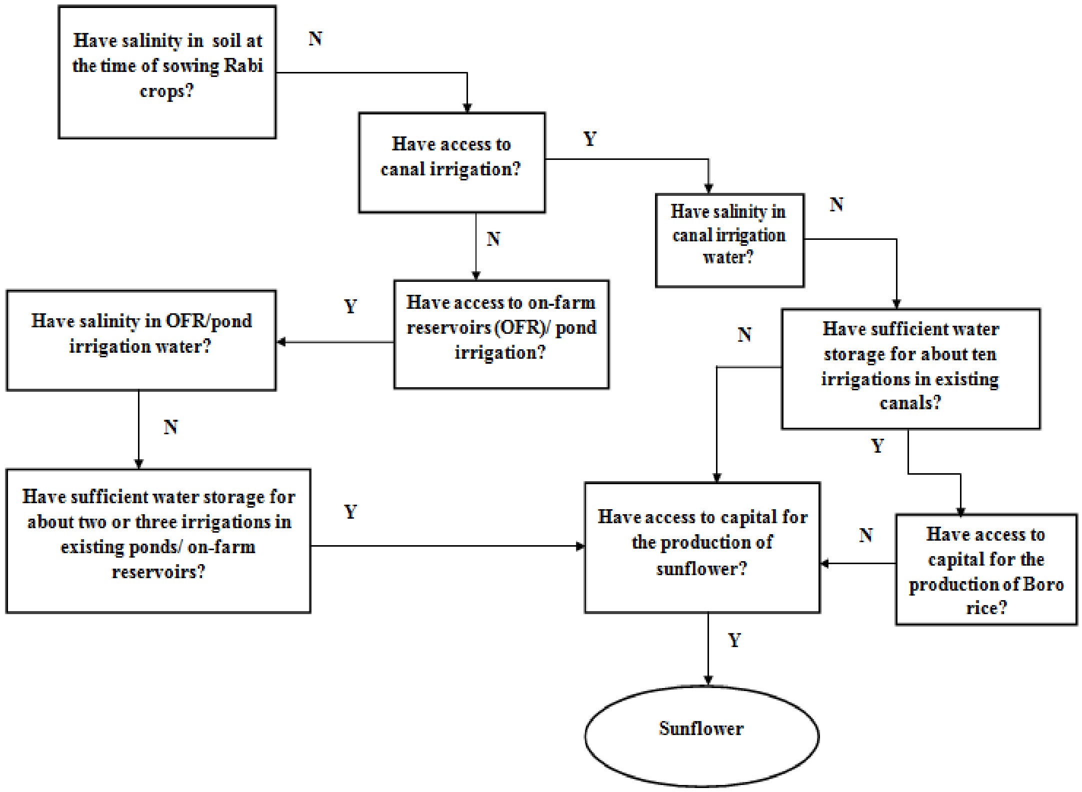


Figure 3: Farmers' decision pathway for the selection of sunflower in coastal area

Case 3 – Selection of Sunflower as a Rabi crop in Pankhali Union (31 Polder): Abdul Hadi Shekh, aged 34

Born and growing up at this union, Abdul Hadi Shekh is living far away from the canal. The farmer got the 5.0 t/ha yields of Aman Dhan. He cultivated the homestead vegetables like as Potato, Tomato, Brinjal etc. This is why; he made an idea that the soil was moderately saline. He constructed the OFR besides the field and had capital to bear the production cost of sunflower. He selected sunflower (Hysun 33) as a Rabi crop. The farmer used two irrigations in the sunflower field. The source of irrigation water was a pond and OFR since he had no access to irrigation water from the canal.

Case 4 – Selection of Sunflower as a Rabi crop in Tildanga Union (31 Polder): Dibakor Golder, aged 40

Born to this union, Dibakor Golder said "I get the vegetables and yield of Aman Dhan, so I am thinking the soil salinity is decreasing. Before 2009, I had some Ghers for shrimp cultivation and I got the yield of Aman dhan around 1.8 t/ha those days. I practiced this cultivation for four years. I was upset and stopped the gear system shrimp cultivation. Now I get the yield of Aman Dhan around 4.0t/ha. After that I decided to cultivate Rabi crop during Rabi season. Since I have no access to canal irrigation water and I have capital to bear the production cost of sunflower. So, I select the sunflower crop as a Rabi crop. The source of irrigation water for sunflower cultivation is OFR and a pond." The farmer used the pond water for homestead activities. So, the farmer did not apply 3rd irrigation.

The decision pathway for the selection of sesame is shown in the Figure 4

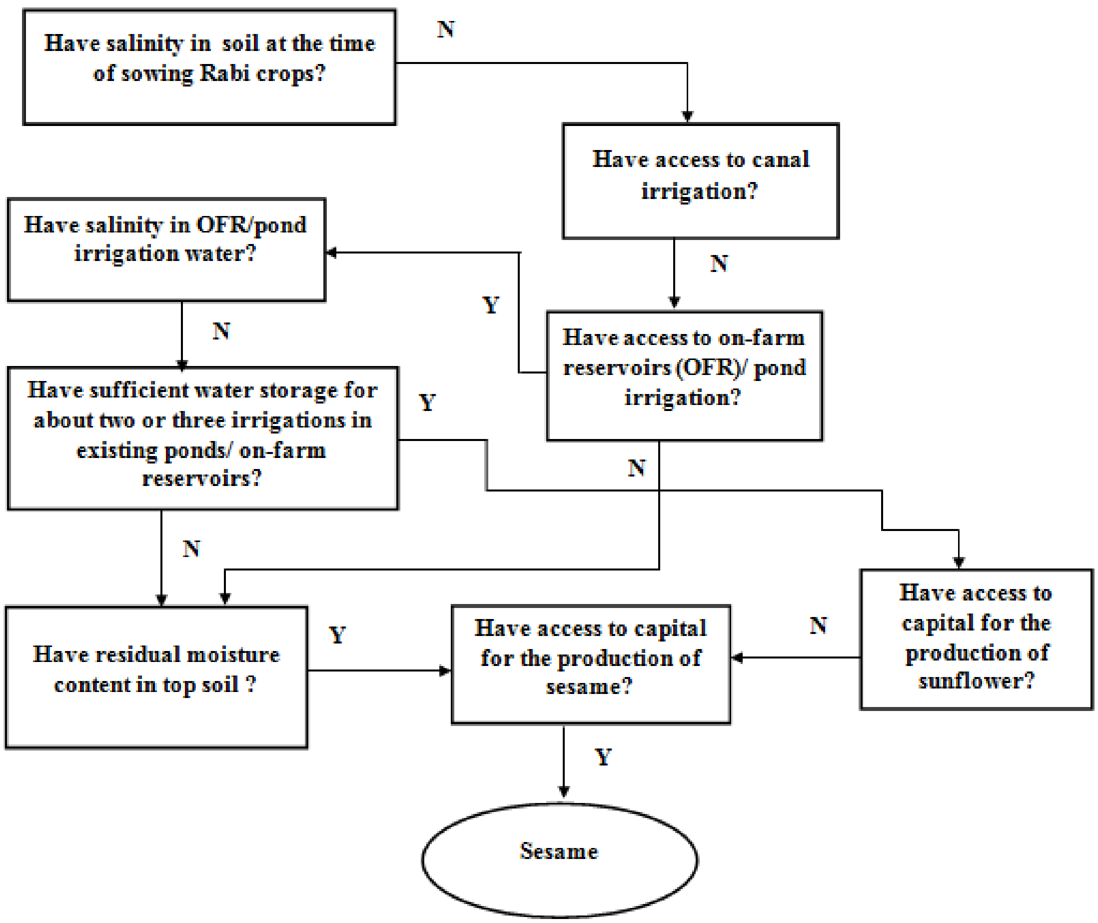


Figure 4: Farmers' decision pathway for the selection of sesame in coastal area

Case 5 – Selection of Sesame as a Rabi crop in Pankhali Union (31 Polder): Md. Muhoshin Sarder, aged 42

Md. Muhoshin Sarder selected sesame as a Rabi crop during 2013-2014 Rabi seasons. The farmer got the yield of Aman dhan between 2 t/ha to 4 t/ha. There were no OFR in the field and he used the pond water for homestead activities. He got training from an NGO and obtained the knowledge of sesame cultivation, how to protect the sesame field from the sudden rainfall. He said “I cultivate the sesame without the use of both fertilizer and irrigation. The sesame acts as an organic fertilizer for the next crop cultivation. I have no access to the source of irrigation water. But the growth of grass indicates that the soil salinity is decreasing. Then I check the Zo condition (moisture) of soil observing the soil clod. Then I decide to cultivate the sesame crop”.

Case 6 – Decision of fallow land during Rabi season at Tildanga Union (31 Polder): Usha Ray aged 37

Usha Ray said “I do not cultivate any Rabi crops during Rabi season, I keep fallow land. Because I think the land is strongly saline during the Rabi season. I cannot grow any vegetables in my homestead garden and I get the yield of Aman Dhan below 1.5 t/ha. The powerful men use the maximum land for Gher system shrimp cultivation, but the marginal, landless, medium and small farmers want to cultivate Rabi crop”.

Case 7 – Decision of fallow land during Rabi season at Suterkhali Union (32 Polder): Mahmud, aged 32

Mahmud said “I do not cultivate any Rabi crops during Rabi season, I keep fallow land. Because I think the land is strongly saline during the Rabi season. I cannot grow any vegetables in my homestead and I get the yield of Aman Dhan below 1.5 t/ha. I have no access to irrigation water. Due to Cyclone Aila, most of the gates of canal are damaged, but still there are no step and care from Government to repair the gate. I work as a day laborer in another district during Rabi season.’’

APPENDIX-D

The Irrigation Water Requirement (IWR) Calculation

The irrigation water requirement of Boro rice:

For land preparation (LP): Jan 1- 14 (14 days), water requirement is 160/14 =11.43 mm/day.

Stage	Duration	ET0 (mm/day)	ET_C= ($ET0 \times K_C$) (mm/day)	S & P (mm/day)	Eff. Rainfall, R_E (mm/day)	CWR= (ET_C+ S& P) (mm/day)	IWR= (CWR-R_E) (mm/day)	Total IWR (mm)
Vegetative Stage (Kc=1.1) :	Jan 15- 31 (16 days)	2.21	2.43	3.50	0	5.93	5.93	94.88
	Feb 1-28 (28 days)	3.05	3.36	3.50	19.2	6.86	00	00
	Mar 1-16 (16 days)	4.52	4.97	3.50	0	8.47	8.47	135.52
Reproductive Stage (Kc = 1.25) :	Mar 17-31 (15 days)	4.52	5.65	3.50	4	9.15	5.15	77.25
	April 1-15 (15 days)	5.60	7.00	3.50	0	10.5	10.50	157.50
Ripening Stage (Kc=1.0):	April 16-30 (15 days)	5.60	5.60	3.50	0	9.10	9.10	136.5
	May 1-15 (15 days)	5.65	5.65	3.50	26.4	9.15	00	00

So, the seasonal IWR and project irrigation water requirements for Boro rice are given below:

IWR Seasonal (mm) = 601.65 + LP

= 601.65 mm + 200 mm =801.65 mm (answer)

Field IWR seasonal (mm) = IWR Seasonal (mm) / efficiency= 801.65/0.6 = 1336 mm

The irrigation water requirement of sunflower:

Stage	Duration	ET0 (mm/day)	ET_C= ($ET0 \times K_C$) (mm/day)		Effective Rainfall, R_E (mm/day)	CWR= ET_C (mm/day)	IWR= ($CWR-R_E$)(mm/day)	Total IWR (mm)
Vegetative Stage (Kc=1.0) :	Jan 20- 31 (12 days)	2.21	2.21		0	2.21	2.21	26.52
	Feb 1-18 (18 days)	3.05	3.05		19.2	3.05	0.00	0
Pre-flowering Stage (Kc = 1.5) :	Feb 19-28 (10 days)	3.05	4.58		4	4.58	0.58	5.8
	March 1-20 (20 days)	4.52	6.78		0	6.78	6.78	135.6
heading Stage (Kc=0.35):	March 21-31 (11days)	4.52	1.58		0	1.58	1.58	17.38
	April 1-19 (19 days)	5.60	1.96		26.4	1.96	0.00	0

So, the seasonal IWR and project irrigation water requirements for sunflower are given below:

Total IWR (mm) = 185.3

Field IWR (mm) = IWR Total (mm) / efficiency= 185.3/0.6 = 308 mm

APPENDIX- E

The Actual Value Collection from the Field Survey

The actual value collection, response to Boro rice producing farmer in Polder 31

Indicators	সম্পূর্ণ	অর্ধেক	দুই তৃতীয়াংশ	এক তৃতীয়াংশ
মাটির সমস্যা আছে কিনা এটা জানার সুযোগ কতটুকু?			√	
বাজারে নতুন জাতের বীজ পাওয়া যায় কিনা?		√		
বাজারে সার,কীটনাশক এবং পোকামাকড়ের ওষুধ পাওয়া যায় কিনা?			√	
কৃষি অফিস থেকে কৃষি বিষয়ক পরামর্শ পায় কিনা?	√			
প্রশিক্ষণের সুযোগ আছে কিনা?				√
উৎসাহিত হন কিনা?	√			
খালে পানি আছে কিনা?	√			
জমির পাশে/পুকুরে পানি আছে কিনা?	√			
লাভ		√		
ফলন	√			
সেচ পানির সুযোগ আছে কিনা?	√			
সেচ পানির পরিমাণ কতটুকু লাগে?	√			
বাজারজাতকরন সহজ কিনা?	√			

Source: Field Survey, 2013-14

Indicators	সম্পূর্ণ	অর্ধেক	দুই তৃতীয়াংশ	এক তৃতীয়াংশ
মাটির সমস্যা আছে কিনা এটা জানার সুযোগ কতটুকু?			√	
বাজারে নতুন জাতের বীজ পাওয়া যায় কিনা?				√
বাজারে সার,কীটনাশক এবং পোকামাকড়ের ওষুধ পাওয়া যায় কিনা?		√		
কৃষি অফিস থেকে কৃষি বিষয়ক পরামর্শ পায় কিনা?	√			
প্রশিক্ষণের সুযোগ আছে কিনা?				√
উৎসাহিত হন কিনা?	√			
খালে পানি আছে কিনা?	-	-	-	-
জমির পাশে/পকুরে পানি আছে কিনা?			√	
লাভ			√	
ফলন			√	
সেচ পানির সুযোগ আছে কিনা?			√	
সেচ পানির পরিমাণ কতটুকু লাগে?		√		
বাজারজাতকরন সহজ কিনা?	√			

The actual value collection, response to sunflower producing farmer in Polder 31

Source: Field Survey, 2013-14

The actual value collection, response to sesame producing farmer in Polder 31

Indicators	সম্পূর্ণ	অর্ধেক	দুই তৃতীয়াংশ	এক তৃতীয়াংশ
মাটির সমস্যা আছে কিনা এটা জানার সুযোগ কতটুকু?				√
বাজারে নতুন জাতের বীজ পাওয়া যায় কিনা?				√
বাজারে সার,কীটনাশক এবং পোকামাকড়ের ওষুধ পাওয়া যায় কিনা?			√	
কৃষি অফিস থেকে কৃষি বিষয়ক পরামর্শ পায় কিনা?		√		
প্রশিক্ষণের সুযোগ আছে কিনা?				√
উৎসাহিত হন কিনা?		√		
খালে পানি আছে কিনা?	-	-	-	-
জমির পাশে/পুকুরে পানি আছে কিনা?	-	-	-	-
লাভ			√	
ফলন			√	
সেচ পানির সুযোগ আছে কিনা?	-	-	-	-
সেচ পানির পরিমাণ কতটুকু লাগে?	-	-	-	-
বাজারজাতকরন সহজ কিনা?	√			

Source: Field Survey, 2013-14

The actual value collection, response to Boro rice producing farmer in Polder 32

Indicators	সম্পূর্ণ	অর্ধেক	দুই তৃতীয়াংশ	এক তৃতীয়াংশ
মাটির সমস্যা আছে কিনা এটা জানার সুযোগ কতটুকু?			√	
বাজারে নতুন জাতের বীজ পাওয়া যায় কিনা?		√		
বাজারে সার,কীটনাশক এবং পোকামাকড়ের ওষুধ পাওয়া যায় কিনা?			√	
কৃষি অফিস থেকে কৃষি বিষয়ক পরামর্শ পায় কিনা?		√		
প্রশিক্ষণের সুযোগ আছে কিনা?				√
উৎসাহিত হন কিনা?		√		
খালে পানি আছে কিনা?			√	
জমির পাশে/পুকুরে পানি আছে কিনা?				√
লাভ		√		
ফলন	√			
সেচ পানির সুযোগ আছে কিনা?	√			
সেচ পানির পরিমাণ কতটুকু লাগে?	√			
বাজারজাতকরন সহজ কিনা?				√

Source: Field Survey, 2013-14

The actual value collection, response to sunflower producing farmer in Polder 32

Indicators	সম্পূর্ণ	অর্ধেক	দুই তৃতীয়াংশ	এক তৃতীয়াংশ
মাটির সমস্যা আছে কিনা এটা জানার সুযোগ কতটুকু?			√	
বাজারে নতুন জাতের বীজ পাওয়া যায় কিনা?				√
বাজারে সার,কীটনাশক এবং পোকামাকড়ের ওষুধ পাওয়া যায় কিনা?		√		
কৃষি অফিস থেকে কৃষি বিষয়ক পরামর্শ পায় কিনা?				√
প্রশিক্ষণের সুযোগ আছে কিনা?				√
উৎসাহিত হন কিনা?				√
খালে পানি আছে কিনা?	-	-	-	-
জমির পাশে/পুকুরে পানি আছে কিনা?			√	
লাভ			√	
ফলন		√		
সেচ পানির সুযোগ আছে কিনা?			√	
সেচ পানির পরিমাণ কতটুকু লাগে?		√		
বাজারজাতকরন সহজ কিনা?	-	-	-	-

Source: Field Survey, 2013-14

The actual value collection, response to sesame producing farmer in Polder 32

Indicators	সম্পূর্ণ	অর্ধেক	দুই তৃতীয়াংশ	এক তৃতীয়াংশ

মাটির সমস্যা আছে কিনা এটা জানার সুযোগ কতটুকু?				√
বাজারে নতুন জাতের বীজ পাওয়া যায় কিনা?				√
বাজারে সার,কীটনাশক এবং পোকামাকড়ের ওষুধ পাওয়া যায় কিনা?			√	
কৃষি অফিস থেকে কৃষি বিষয়ক পরামর্শ পায় কিনা?				√
প্রশিক্ষণের সুযোগ আছে কিনা?				√
উৎসাহিত হন কিনা?				√
খালে পানি আছে কিনা?	-	-	-	-
জমির পাশে/পুকুরে পানি আছে কিনা?	-	-	-	-
লাভ			√	
ফলন			√	
সেচ পানির সুযোগ আছে কিনা?	-	-	-	-
সেচ পানির পরিমাণ কতটুকু লাগে?	-	-	-	-
বাজারজাতকরন সহজ কিনা?	-	-	-	-

Source: Field Survey, 2013-14

APPENDIX-F

The Standardized Value Calculation from the Field Survey

The Standardized value calculation, response to Boro rice, sunflower and sesame producing farmer in Polder 31

Assets	Indicators	Boro rice		sunflower		sesame	
		Actual value	Standard value	Actual value	Standard value	Actual value	Standard value
Social	Access to soil information	0.67	0.51	0.67	0.51	0.33	0.66
	Availability of effective extension services	1.00	1.00	1.0	1.00	0.50	0.25
	Availability of new varieties in the market	0.50	0.25	0.33	0.66	0.33	0.66
	Availability of fertilizer and pesticides in the market	0.67	0.51	0.50	0.50	0.67	0.51
Human	Training of the farmers	0.33	0.66	0.33	0.66	0.33	0.66
	Motivation of the farmers	1.00	1.00	1.00	0.06	0.50	0.50
Natural	Canal irrigation water	1.00	1.00	0.00	0.00	0.00	0.00
	OFR/Pond irrigation water	1.00	1.00	0.67	0.51	0.00	0.00
Financial	Profit	0.5	0.25	0.67	0.51	1.00	1.00
	Yield	1.00	1.00	0.50	0.25	0.67	0.51
Physical	Access to marketing network	1.00	1.00	1.00	1.00	1.00	1.00
	Irrigation water facility	1.00	1.00	0.67	0.51	0.00	0.00
	Amount of irrigation water	1.00	1.00	0.50	1.00	0.00	0.00

As example,

For Boro rice producing farmers in Polder 31, the indicator is access to soil information, where

Actual value = 0.67

Minimum value = 0.33

And maximum value = 1.00

From equation 9,

Index value (standardized value) = $\frac{Actual\ value - minimum\ value}{Maximum\ value - minimum\ value}$

So, the standardized value of the above indicator is 0.51

From Table 4.15, the weighing of the indicator is 0.06

From equation 10,

FLSI = (Ssvi × Wi) + (Hsvi × Wii) + (Nsvi × Wiii) + (Fsvi × Wiv) + (Psvi × Wv)

Now, the standardized value of social asset sub-index (one indicator)

= The standardized value of the indicator * the weighing of the indicator

= 0.51 × 0.06

=0.03

Thus, the each indicator has been calculated.

The calculation of the Table 4.20

Now from Table 4.18, the social assets value for Boro rice including four indicators

= 0.03 + 0.04 + 0.01 + 0.01 = 0.09

Thus each assets has been calculated for the respective crops.

The Standardized value Calculation, response to Boro rice, sunflower and sesame producing farmer in Polder 32

Assets	Indicators	Boro rice		sunflower		sesame	
		Actual value	Standard value	Actual value	Standard value	Actual value	Standard value
Social	Access to soil information	0.67	0.51	0.67	0.51	0.33	0.66

	Availability of effective extension services	0.50	0.25	0.33	0.66	0.33	0.66
	Availability of new varieties in the market	0.50	0.75	0.33	0.75	0.33	0.49
	Availability of fertilizer and pesticides in the market	0.67	1.00	0.50	0.49	0.67	0.51
Human	Training of the farmers	0.33	0.66	0.33	0.49	0.33	0.66
	Motivation of the farmers	0.50	0.75	0.33	0.49	0.33	0.49
Natural	Canal irrigation water	0.67	0.51	0.00	0.00	0.00	0.00
	OFR/Pond irrigation water	0.33	0.66	0.67	0.67	0.00	0.00
Financial	Profit	0.50	0.75	0.67	0.51	1.00	1.00
	Yield	1.00	0.12	0.50	0.50	0.67	0.51
Physical	Access to marketing network	0.33	0.66	0.00	0.00	0.00	0.00
	Irrigation water facility	1.00	1.00	0.67	1.00	0.00	0.00
	Amount of irrigation water	1.00	1.00	0.50	0.25	0.00	0.00

APPENDIX-G

The Standardized Value Calculation for Pentagon from the Field Survey

The Standardized value calculation for pentagon, response to Boro rice, sunflower and sesame producing farmer in Polder 31

Assets	Indicators	Boro rice		Sunflower		Sesame	
		Actual value	Standard value	Actual value	Standard value	Actual value	Standard value
Social	Access to soil information	0.67	0.20	0.67	0.20	0.33	0.26
	Availability of effective extension services	1.00	0.27	1.0	0.27	0.50	0.07
	Availability of new varieties in the market	0.50	0.05	0.33	0.13	0.33	0.13
	Availability of fertilizer and pesticides in the market	0.67	0.07	0.50	0.07	0.67	0.07
Human	Training of the farmers	0.33	0.36	0.33	0.36	0.33	0.36
	Motivation of the farmers	1.00	0.46	1.00	0.03	0.50	0.23
Natural	Canal irrigation water	1.00	0.63	0.00	0.00	0.00	0.00
	OFR/Pond irrigation water	1.00	0.37	0.67	0.19	0.00	0.00
Financial	Profit	0.5	0.11	0.67	0.23	1.00	0.45
	Yield	1.00	0.55	0.50	0.14	0.67	0.28
Physical	Access to marketing network	1.00	0.25	1.00	0.25	1.00	0.25
	Irrigation water facility	1.00	0.33	0.67	0.17	0.00	0.00
	Amount of irrigation water	1.00	0.42	0.50	0.42	0.00	0.00

The Standardized value calculation for pentagon, response to Boro rice, sunflower and sesame producing farmer in Polder 32

Assets	Indicators	Boro rice		Sunflower		Sesame	
		Actual value	Standard value	Actual value	Standard value	Actual value	Standard value
Social	Access to soil information	0.67	0.21	0.67	0.21	0.33	0.27
	Availability of effective extension services	0.50	0.05	0.33	0.12	0.33	0.12
	Availability of new varieties in the market	0.50	0.07	0.33	0.07	0.33	0.04
	Availability of fertilizer and pesticides in the market	0.67	0.32	0.50	0.16	0.67	0.16
Human	Training of the farmers	0.33	0.29	0.33	0.22	0.33	0.29
	Motivation of the farmers	0.50	0.42	0.33	0.27	0.33	0.27
Natural	Canal irrigation water	0.67	0.33	0.00	0.00	0.00	0.00
	OFR/Pond irrigation water	0.33	0.23	0.67	0.23	0.00	0.00
Financial	Profit	0.50	0.44	0.67	0.30	1.00	0.59
	Yield	1.00	0.41	0.50	0.20	0.67	0.21
Physical	Access to marketing network	0.33	0.35	0.00	0.00	0.00	0.00
	Irrigation water facility	1.00	0.21	0.67	0.21	0.00	0.00
	Amount of irrigation water	1.00	0.26	0.50	0.26	0.00	0.00

As example,

For Boro rice producing farmers in Polder 31, the indicator is access to soil information, where the standardized value of the above indicator is 0.51 from the equation 9 (APPENDIX-F),

From the Table 4.15, the weighing of the indicator is 0.06 and total weight of the social assets is 0.15

Now, for the pentagon the standardized value of social asset (one indicator)

$$= \text{The standardized value of the indicator} \times \frac{\text{the weighing of the indicator}}{\text{total weight of the social assets}}$$

$$= 0.51 \times \frac{0.06}{0.15}$$

=0.20

Thus, the each indicator has been calculated for the pentagon.

The Calculation of Farmers Livelihood Security Index (FLSI)

From APPENDIX-F, the social assets value for Boro rice is 0.09

From the Table 4.20, human, natural, financial and physical assets value for Boro rice is 0.11, 0.19, 0.19 and 0.25 respectively.

Now, for the calculation of the Table 4.22, FLSI for Boro rice producing farmers' in Polder 31

= 0.09 + 0.11 + 0.19 + 0.19 + 0.25 = 0.83

Thus, the FLSI has been calculated for each crop producing farmers both in Polder 31 and Polder 32.