Evaluation of the Agricultural and Socio-economic Impacts Due to Mohonpur Rubber Dam Project in Dinajpur District of Bangladesh

MS Thesis 2021

Exam Roll: 111106

R.K. Shishir

Department of Geography and Environment

University of Dhaka

Submitted By

Rifayat Khan Shishir

Exam Roll: 111106

MS Thesis: 2021

MS Session: 2020-21

Supervisor

Dr. Md. Faruk Hossain

Associate Professor

Department of Geography and Environment

University of Dhaka

This Thesis is submitted to the Department of Geography and Environment, University of Dhaka for the partial fulfillment of the requirements for the degree of Master of Science (MS).

Certificate of Approval

This thesis entitled "*Evaluation of the Agricultural and Socio-economic Impacts Due to Mohanpur Rubber Dam Project in Dinajpur District of Bangladesh*" by Rifayat Khan Shishir, Exam Roll. 111106, Reg No. 2016-118-678, and session 2020-21 is hereby approved as a creditable study of Geography and Environment carried out and presented in a manner satisfactory to warrant its acceptance as a pre-requisite for the degree for which it has been submitted.

Supervisor

Dr. Md. Faruk Hossain
Associate Professor
Department of Geography and Environment
University of Dhaka

Candidate's Declaration

In presenting this thesis in partial fulfillment of the requirements for a postgraduate degree from the University of Dhaka, I agree that the seminar of the department may take it freely available for inspection.

Moreover, I hereby certify that this entire material belonging to my Master's Thesis, which is now submitted for assessment, is entirely my own work and has not been taken from the contents of others save to the extent that such work has been cited and acknowledged within the text of my elaboration and development.

Finally, I declare it has not been submitted in part or in whole to any other university for assessment or for the award of any other academic degrees.

Rifayat Khan Shishir

Exam Roll: 111106

MS Thesis: 2021

MS Session; 2020-21

Acknowledgment

I am profoundly grateful to Almighty Allah (SWT) for enabling me to devote myself in every step of this research. Then, I would like to extend my heartfelt gratitude to Dr. Md. Faruk Hossain, the supervisor of this research, Associate Professor of the Department of Geography and Environment, University of Dhaka. Your invaluable expertise, unwavering encouragement, and insightful feedback have been instrumental in shaping the direction of this research. Your guidance and mentorship have truly been a cornerstone of my academic growth.

I would like to dedicate a special note of gratitude to my father, Md. Shahidullah Khan. You have been a true blessing in my life. I would also like to convey my gratitude to two remarkable women who have been my unwavering pillars of support throughout this journey.

To my mother Parveen Khan, your boundless love, encouragement, and sacrifices have been the foundation upon which I've built my aspirations. Your guidance and belief in me have fueled my determination to achieve this milestone.

To my wife Sayma Afroz, your patience, understanding, and constant encouragement have been instrumental in helping me navigate the challenges of this academic endeavor. Your unwavering support and sacrifices have been a source of strength and inspiration. Both of you have played pivotal roles in shaping my academic and personal growth. I am truly fortunate to have such strong and supportive women in my life.

I would also like to acknowledge the endless support and caring that I got from my sister-in-law, Mrs. Swapna Akhter and my brother, Tusher.

I would also like to convey my strong gratitude to my younger brother, Rudro.

This is full-funded research. Funding credit goes to the Bangladesh Red Crescent Society. '*Bangladesh Red Crescent Society (BDRCS) Urban Fellowship Grant*' was awarded for this particular research under the project of '*Urban Resilience Building through Research, Knowledge, and Innovation*'.

Last but not least, my sincere recognition to all the participants, who spent their valuable time responding to my research questions which allowed me smoothly conduct the field survey.

Abstract

The Mohonpur Rubber Dam Project of Dinajpur District was commissioned by the Ministry of Agriculture and was implemented by Local Government Engineering Department in 2014. The project has a total irrigation coverage of 1000 ha for Boro rice cultivation. The objectives of this study were to evaluate the impacts of the MRDP on agriculture and the socioeconomic conditions of the people. The impacts were evaluated following a mixed-method approach. The agricultural impacts were evaluated using some agricultural indicators and the socioeconomic impacts were analyzed on the basis of the changes after the installation of the dam. Results showed farming was the primary profession accounting for 56 percent, while professional dynamism existed. The level of education was found very low with 67 percent of respondents having primary and lower secondary education. About 88 percent were nuclear families consisting of 3-4 members. Except for matrimonial migration, it was very low. Agriculture experienced a favorable impact, with a 31 percent rise in yield production contributing to the enhanced income of the locals. Approximately 45 percent observed a rise in income as irrigation costs reduced, increased yield production, and the availability of fish increased. These factors collectively improved the economic conditions of the people. About 88 percent of the people utilized dam reservoirs for irrigation alleviating stress on groundwater sources. The rubber dam has posed some issues with riverbank erosion and flooding being notable concerns. A correlational matrix was generated to present correlations among variables. The performance was evaluated by means of some technical parameters Command Area Efficiency (CAE), Irrigation Efficiency (IE), Benefit-cost Ratio (BCR), and Yield Efficiency (YE). It was observed from the study that the CAE of Mohonpur Scheme, and Bhabki Scheme were 36.36 percent and 49.9 percent respectively. IE was 0.57 percent indicating very low performance. BCR of Mohonpur and Bhabki schemes were 2.3 and 2.49, suggesting Mohonpur Scheme was substandard. However, YE was 93.98 percent indicating the yield-producing performance was very close to the estimated yield production. Hence, a number of impacts and performance constraints were identified along with recommendations to attain estimated results.

Abbreviations

AHP- Analytical Hierarchy Process

BADC- Bangladesh Agricultural Development Corporation

BARC- Bangladesh Agricultural Research Council

BCR- Benefit Cost Ratio

BIADP- Barind Integrated Area Development Project

BIC - Beijing IWHR Corporation

BRDP- Buraghat Rubber Dam Project

BRRI- Bangladesh Rice Research Institute

BWDB- Bangladesh Water Development Board

CAE- Command Area Efficiency

CRDP- Chowmohani Rubber Dam Project

CRE- Cimanuk River Estuary

DAP- Di-ammonium Phosphate

DM- Deem Machines

DTW- Deep Tube Wells

EPC- Equilibrium Phosphorus Concentrations

EWS- Early Warning Systems

FLAC- Fast Lagrangian Analysis of Continua

GoB- Government of Bangladesh

HIES- Household Income and Expenditure Survey

HTW- Hand Tube well

HYV- High-Yielding Variety

ICAR- Indian Council of Agricultural Research

IFMD- Inflatable Flexible Membrane Dams

IWHR- Water Resources and Hydropower Research

KRRDP- Kawraid River Rubber Dam Project

LCC- Life Cycle Cost

LES- Large Eddy Simulation

LGED- Local Government Engineering Department

LHS- Liujianfang Hydrometric Station

LLP- Low Lift Pump

LRE- Liao River Estuary

LRS- Liao River Station

MoA- Ministry of Agriculture

MPO- Master Plan Organization

MPR- Management Performance Ratio

NGO- Non-government Organization

NWMP- National Water Management Plan

NWPP- National Water Plan Project

NWR- North Western Region

OFWM- On-Farm Water Management

PIDA- Public Irrigation Development Activities

RCC- Roller Compacted Concrete

RWMT- River Water Management Tool

SAR- Shatt-al-Arab River

SHP- Small Hydropower

SM- Strategic Management

STW- Shallow Tube Well

SWOT- Strengths, Weaknesses, Opportunities, Threats

TBS- The Business Standard

TDS- Total Dissolved Solids

TSP- Triple superphosphate

VOF- Volume of Fluid

WUE- Water Use Efficiency

YE- Yield Efficiency

Table of Contents

Chapter 01: Introduction ..... (1-8)
1.1 Background of the Study 1
1.2 Statement of the Problem 4
1.3 Significance of the Study 5
1.4 Objectives of the Study 6
1.5 Research Questions 6
1.6 Limitations of the Study 6
1.7 Organization of the Thesis 7
1.7.1 Chapter 1: Introduction 7
1.7.2 Chapter 2: Literature Review 7
1.7.3 Chapter 3: Methodology 7
1.7.4 Chapter 4: Profile of the Study Area 8
1.7.5 Chapter 5: Results and Discussion 8
1.7.6 Chapter 6: Conclusion and Recommendations 8
Chapter 02: Literature Review ..... (9-24)
2.1 Introduction 9
2.2 Rubber Dam 9
2.3 Uses of Rubber Dam 11
2.4 Rubber Dam: Global and Regional Context 13
2.5 Rubber Dam: Local Context 20
2.6 Performance Constraints of Rubber Dams 23
2.7 Conclusion 24
Chapter 03: Methodology ..... (26-34)
3.1 General 26
3.2 Research Design 26
3.3 Data Sources 27
3.4 Data Collection Techniques 27
3.5 Primary Data and Information Collection 27
3.5.1 Semi-structured Questionnaire for the Households 27
3.5.2 Pre-testing of the Questionnaire 28
3.5.3 Sample Size Determination for Household Survey 28
3.5.4 Focus Group Discussion (FGD) 29
3.5.5 Key Informant Interview (KII) 30
3.6 Secondary Data and Information Collection 30

3.7 Data Analysis....30
3.7.1 Weighted Average Index....31
3.7.2 Quantitative Data Analysis....32
3.7.3 Correlation Matrix Analysis....33
3.8 Theoretical Calculations....33
3.8.1 Command Area Efficiency (CAE)....33
3.8.2 Irrigation Efficiency (IE)....33
3.8.3 Benefit-Cost ratio (BCR)....33
3.8.4 Yield Efficiency (YE)....34
Chapter 04: Profile of the Study Area....(35-39)
4.1 Introduction....35
4.2 Selection of the Site....35
4.3 General Information of Upazilas....36
4.4 Locations of the Study Area....37
4.5 Conclusion....39
Chapter 05: Results and Discussion....(40-91)
5.1 Profile of the Respondents....40
5.2 Respondents' Age Range....40
5.3 Profession of the Respondents....41
5.4 Respondents' Education....42
5.5 Family Information of the Respondents....42
5.6 Family Size of the Respondents....43
5.7 Professional Change Among the Respondents....44
5.8 Residential Period....45
5.9 Migration Information....46
5.10 Destination of the Migrated People....47
5.11 Migration to the Study Area....47
5.12 Causes of Migration....48
5.13 Yearly Income of the Respondents....49
5.14 Increase in Yearly Income....50
5.15 Amount of Increased Income....51
5.16 Reasons for Increased Income....51
5.17 Family Income of the Respondents....52
5.18 Income Amount of Family Member....53
5.19 Poverty Reduction of the Respondents....54

5.20 Family Employment Opportunity Among the Respondents 55
5.21 Changes in Land Uses 56
5.22 Loan Information of the Respondents 57
5.23 Information regarding Loan Media 58
5.24 Amount of the Loan 59
5.25 Saving Information of the Respondents 59
5.26 Amount of the Annual Savings 60
5.27 Saving Media 61
5.28 Communication Improvement after Installation of the Dam 62
5.29 Environmental Impacts Due to Mohonpur Rubber Dam 63
5.30 Environmental Impacts 64
5.31 Overall Impacts of the Mohonpur Rubber Dam Project 65
5.33 Increase of Crop Land due to Rubber Dam 69
5.34 Amount of Increased Crop Lands 70
5.35 Seasons of Crop Cultivation 70
5.36 Variation and Name of the Seasonal Crops 71
5.37 Increase of Crop Production 72
5.38 Amount of Increased Crop Production 73
5.39 Changes in Crop Variety 74
5.40 Reduction of Irrigation Cost 75
5.41 Cost of Irrigation in Per Bigha Land 77
5.42 Sources of Irrigation 78
5.43 Performance of Mohonpur Rubber Dam 79
5.44 Changes in the Sources of Irrigation Due to Mohonpur Rubber Dam 81
5.45 Increase in the Availability of Fish Population 82
5.46 Some Additional Issues 84
5.47 Profitability of Rubber Dam 84
5.48 Correlation among Variables 86
5.49 Theoretical Calculations 87
5.49.1 Command Area Efficiency (CAE) 87
5.49.2 Irrigation Efficiency (IE) 88
5.49.3 Benefit-Cost Ratio (BCR) 89
5.49.4 Yield Efficiency (YE) 91
5.50 Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) Information 91
Chapter 06: Conclusion and Recommendations ..... (94-97)

6.1 Introduction 94
6.2 Summary of the Research 94
6.3 Recommendations 97
6.4 Conclusion 97
References 99
Appendix 105
Appendix - A 114
Appendix -B 115

List of Tables

Table 1: Perception Index Stages 31
Table 2: Population of the Study Villages 36
Table 3: General Information of Upazilas 36
Table 4: Locations of Study Area 37
Table 5: Profile Details of the Respondents 40
Table 6: Professional Change before and after rubber dam installation 45
Table 7: Impacts of Mohonpur Rubber Dam Project in Weighted Average Index (WAI) 67
Table 8: Name of the Seasonal Crop Cultivated in the Study Area 72
Table 9: Crop Production Scenario Before and After Dam Implementation (Average amount of respondent's response) 74
Table 10: Changes in crop variety before and after the implementation of Rubber dam as mentioned by the respondents 75
Table 11: Overall Performance Analysis of the Mohonpur Rubber Dam Project by WAI 80
Table 12: Irrigation Water Sources Before and After Dam Installation according to the responses of Respondents 82
Table 13: Some Additional Issues according to the responses of Respondents 84
Table 14: Correlation Matrix among Variables 86
Table 15: Command Area Efficiency (CAE) of Mohonpur Rubber Dam Project 87
Table 16: Calculation of Net Irrigation Requirement of Crop 88
Table 17: Temporary Lease Money (Locally known as "Khaykhelashi" of three villages with the causes of variation according to the opinion of respondents 89
Table 18: Performance of Benefit-cost ratio of Schemes of the Mohonpur Rubber Dam Project (BCR for Land Owners as they don't have to pay lease money) 90
Table 19: Performance of Benefit-cost ratio of Schemes of the Mohonpur Rubber Dam Project (BCR for Landless farmers as they have to pay lease money to land owners) 90
Table 20: Yield Efficiency (YE) Calculation 91

Table 21: Information (Dominant Group) Collected from KIIs and FGDs 91
Table 22: Performance Constraints and Resulting Problems of the Mohonpur Rubber Dam Project .. 92

List of Maps

Map 1: Satellite Map of Mohonpur Rubber Dam 38
Map 2: Study Area Map 39

List of Figures

Figure 1: Types of Rubber Dams 11
Figure 2: Age of the Respondents 40
Figure 3: Respondent's Profession 41
Figure 4: Respondents' Education Level 42
Figure 5: Respondent's Family Type 43
Figure 6: Family Size of the Respondents 44
Figure 7: Professional Change among the Respondents 44
Figure 8: Residential Period of the Respondents 46
Figure 9: Migration Information of the Respondents 46
Figure 10: Destination of the Migrated People 47
Figure 11: Migration to the Study Area 48
Figure 12: Causes of Immigration 49
Figure 13: Yearly Income of the Respondents 49
Figure 14: Increase in yearly Income 50
Figure 15: Amount of the Increased Income 51
Figure 16: Reasons for Increased Income 52
Figure 17: Family Income of the Respondents 53
Figure 18: Income Amount of the Family members 54
Figure 19: Poverty Reduction in Percentage 54
Figure 20: Family Employment Opportunity among Respondents 55
Figure 21: Change in Land Uses 56
Figure 22: Loan Receiving Status 57
Figure 23: Loan Media 58
Figure 24: Loan Amount 59
Figure 25: Savings Status of the Respondents 60
Figure 26: Amount of the Annual Savings 60
Figure 27: Savings Media 61

Figure 28: Communication Improvement 62
Figure 29: Environmental Impacts of Rubber Dam 63
Figure 30: Environmental Impacts 64
Figure 31: Impacts of Mohonpur Rubber Dam 66
Figure 32: Impacts of Mohonpur Rubber Dam Project by WAI 67
Figure 33: Land Ownership of the Respondents 68
Figure 34: Amount of Land 69
Figure 35: Increase of Crop Land due to Rubber Dam 69
Figure 36: Increased Amount of Crop Land 70
Figure 37: Seasonal Variation of Crop Cultivation 71
Figure 38: Increase in Crop Production 72
Figure 39: Amount of Increased Crop Production 73
Figure 40: Changes in Crop Category 74
Figure 41: Reduction of Irrigation Cost due to Mohonpur Rubber Dam 75
Figure 42: Irrigation Cost in Taka 77
Figure 43: Sources of Irrigation in the Study Area 78
Figure 44: Overall Performance of Mohonpur Rubber Dam Project by WAI 80
Figure 45: Changes in the Sources of Irrigation 81
Figure 46: Increase in the Availability of Fish Population due to Dam Reservoir 83
Figure 47: Profitability of Rubber Dam 85

List of Photos

Photo 1: Data Analysis Using IBM SPSS Statistics Software 32
Photo 2: Irrigation Calculating Software developed by FAO 34
Photo 3: Mohonpur Rubber Dam Project 38
Photo 4: Litchi Garden which was barren land before the installation of rubber dam 56
Photo 5: Riverbank Erosion in the Study Area 65
Photo 6: Riverbank Erosion in Dhakail Village 66
Photo 7: Irrigation Drainage implemented by BADC 76
Photo 8: Water Withdrawal from Dam Reservoir for Irrigation 79
Photo 9: Water Abstraction from Dam Reservoir for Irrigation 82
Photo 10: Fishers Catching Fish in the Dam Reservoir 84
Photo 11: Key Informant Interviews 105
Photo 12 : FGDs and Fishing, Farming Lands 105

Chapter 01: Introduction

1.1 Background of the Study

Bangladesh is a densely populated agro-based country that strongly depends on local crop yield. The people of the country are increasing at a rate of about 1.22 percent yearly (BBS, 2022). To follow along with the growing population, Bangladesh needs to produce excessive amounts of grains. Bangladesh heavily relies on groundwater for rice production, which is a crucial aspect of the country's agricultural sector. Rice is the staple food in Bangladesh, and it is essential for ensuring food security and meeting the dietary needs of its large population. The increased food supply derives mainly from the High Yielding Variety (HYV), and it needs additional irrigation. Groundwater is used extensively for irrigation purposes, especially in the dry season when surface water sources may not be readily available. The practice of groundwater irrigation has grown significantly in Bangladesh over the past few decades, as it allows farmers to cultivate multiple crops per year, boosting agricultural productivity. So, over-exploitation of underground water becomes inevitable. This irrigation mainly comes from two sources: groundwater water and surface water. Groundwater depletion sharply leads to a freshwater crisis, and finally affects the socio-economic conditions.

More than 97 percent of the world's freshwater supply comes from groundwater (Jakeman et al., 2016). Seventy percent of the world's freshwater is utilized in agriculture (Khokhar, 2017). It is estimated that between 45 and 70 percent of irrigation water comes from groundwater (Wada et al., 2014; Lall et al., 2020), and both groundwater abstraction and use are on the rise across the globe. Overuse of groundwater for irrigation is a major cause of depletion and heavily impacts groundwater levels (Mojid et al., 2021). A decrease in groundwater levels poses a danger to the long-term viability of aquifers (Akther et al., 2009; Mojid et al., 2021). The future availability of groundwater resources is anticipated to be significantly influenced by climate change (Goderniaux et al., 2011; Taylor et al., 2013; Abdulla et al., 2018; Jannis et al., 2021). Since surface water is in short supply during the dry season in Bangladesh, the country has turned to groundwater-based irrigation to grow high-yielding rice (Scott and Sharma, 2009; IRRI, 2010). According to Michael and Voss (2009), groundwater is a crucial resource for satisfying the needs of both industries and households.

According to BBS (2017), it caters to 79 percent of the water requirements for households, livestock, industries, and irrigation purposes. In the fiscal year 2012-2013, groundwater served

as the primary source of irrigation for more than 97 percent of the nation's total irrigated land, which constituted around 85 percent of the net cultivable area. Notably, the Northwest (NW) region accounted for a significant proportion of this overall groundwater utilization (Mainuddin et al., 2013). Nearly all of the water used for irrigation in this area originates from underground sources. The northwest part of Bangladesh has an even greater groundwater-to-surface water usage ratio (Paul and Hasan, 2020). The Northwestern area exhibits spatial variability in groundwater availability, with the North-Western half receiving around 100 percent of its water needs from groundwater sources, while the South-Western part relies on groundwater for approximately 40 percent of its water supply (Kirby et al., 2013). The decline in surface water availability may be attributed to two primary factors: the extensive use of water for agricultural irrigation during the dry season and the recurrent incidence of droughts upstream of transboundary rivers. Therefore, groundwater is crucial for irrigation and other needs in the Northwest. Groundwater depletion in the northwestern part of Bangladesh, particularly in the region of Rajshahi and Rangpur divisions, has been a significant concern due to excessive irrigation practices. This region is known for its intensive agricultural activities, with rice being a dominant crop, and groundwater being the primary source of irrigation.

Since the availability of groundwater is decreasing, sustainable agricultural management becomes necessary. Moreover, Climatological data indicates the decreasing trend of rainfall in the Northwestern region especially in the Dinajpur district, which also exaggerates the depletion of groundwater. The annual rainfall trend is decreasing at an average rate of 8.946 mm in Rajshahi, 14.170 mm in Rangpur, and 11.030 mm in Dinajpur, respectively. It also shows that dry days are becoming more common in Bangladesh, with rates of +0.370, +0.096, and +0.205 years each year in the Rajshahi, Rangpur, and Dinajpur districts respectively. Since 1990, there has been a consistent upward trend in the average annual temperature in Dinajpur, with an annual increase of +0.014°C. As a result, the drought in northwest Bangladesh might get worse (Karmakar, 2019). Groundwater levels in Dinajpur drop by three to six feet annually during the dry season, as reported by the Department of Public Health Engineering in 2022. Not just during the dry season but also during the monsoon, the level often drops by a foot or two every five years. The organization reports that over the previous decade, groundwater levels in Dinajpur have dropped by two to four feet, leading to an increase in irrigation costs of between six and eight percent in certain areas (TBS, 2022).

However, in order to reduce the pressure on the groundwater table and make irrigation economically profitable Government of Bangladesh (GoB) has formulated a National Water

Management Plan (NWMP). As per the National Water Management Plan (NWMP), considering the lower implementation cost in comparison with its economic viability, several rubber dam projects were implemented across the country. The main purpose of the structure is to facilitate irrigation and reduce dependency on groundwater. Mohanpur Rubber Dam on the Atrai River in Dinajpur district is subject to the study. The dam was initiated over the Atrai River by the Ministry of Agriculture (MoA) in 2011. In 2014, the project was put into action by the LGED (Local Government Engineering Department). It is located between two upazilas, Sadar and Chirirbandar and the dam is 135 meters long and 4 meters high and it creates a 44 km long reservoir in the river (TBS, 2022)

Rubber Dams, a kind of fabric dam, are currently widely used across the globe for an assortment of purposes (IWHR, 1994). Inflatable dams may be inflated with air, water, or a mixture of the two, and are constructed from a flexible, cylindrical, synthetic rubberized material linked to a hard foundation. Due to its portability and ease of building, the usage of rubber dams is gaining popularity (Chougule et al., 2018). Rubber dams are constructed with the purpose of boosting the water level in a river and redirecting a portion or the whole of its flow into a supply canal or conduit, hence facilitating its utilization for irrigation, domestic, or industrial purposes. These dams function as barriers or obstructions, sometimes referred to as weirs or barrages (Tam, 1997). In the early 1950s, American engineer Norman Imbertson invented the inflatable flexible membrane dams (IFMD, also referred to as rubber dams). They are installed to redirect water for many purposes, including irrigation, flood prevention, aquifer recharging, fish passage, protection of low-lying coastal communities from tidal floods, and the temporary raising of existing dams. Rubber dams may be built more quickly and for less money than conventional concrete or brick dams. When compared to traditional water management methods, rubber dams offer their own set of benefits. Effective water conservation is adjusting the volume of stored water up or down depending on the situation (Hoque, 2010).

It's a new take on hydraulics that differs from a number of common dams and barrages that use gated or ungated spillways and weirs to discharge surplus water. These are not technically dams, but rather water-retention constructions composed of high-strength cloth adhered with rubber; when filled with water or air and secured to the concrete floor of a basement, the bag expands like a balloon. In addition to preventing flooding, rubber dams may be utilized for flood discharge by discharging excess water over the dam's body after the dam bag has been emptied of its contents (Chougule et al., 2018).

There are around 30 rubber dam projects across the country implemented by Local Government Engineering Department (LGED). Most dams were established for irrigational purposes and to increase food production for ensuring food security. The Mohonpur Rubber Dam project was initiated in 2011 and completed in 2014 by LGED. Total project expenditures came to Tk 1751.15 lakh. The price tag included not just the dam's construction, but also the installation of ancillary infrastructure essential to its operation. The dimensions of the rubber dam are as follows: 135 meters in length, 4 meters in height, and a width of 12mm for the rubber bag used to build the dam. The project was initiated to supply irrigation facilities to Boro paddy during the dry season. Thus, the dam remains open only for 4 months during the Rabi crops. According to LGED, the rubber dam is supplying irrigation facilities up to 1000 hectares of cultivable land where 500 hectares of land can use irrigation water without using the pump and 500 hectares need to use the pump for irrigation. Direct beneficiary members are 700, while 4000 people are living in the commanding area. It is estimated that about 2000 tons/yearly of Boro paddy will increase, which financial value is almost Tk300 lakh. Along with these positive factors of Mohonpur Rubber Dam, there are some serious issues risen along the banks of the Atrai and Kakra rivers, claiming to enhance the riverbank erosion of three villages leaving many to become landless. Three villages close to the rubber dam experienced tremendous riverbank erosion which is Parameshwarpur of Sadar Upazila, Dhakail, and Bhabki of Chirirbandar Upazilla. Though the impacts of Mohonpur Rubber Dam are multivarious as it facilitates the irrigation process making agriculture more viable, reduces pressure on the groundwater table by emphasizing the uses of surface water, and finally affects the socio-economic conditions of local people, and it needs to be studied that how locals perceive its impacts. In light of the fact that it has been more than eight years since the Mohonpur Rubber Dam was first put into place, it is important to undertake the study to assess the agricultural and socioeconomic impacts of the dam.

1.2 Statement of the Problem

Since Rubber Dam technology is comparatively new in Bangladesh, the adoption of the technology is on the rise. Primarily, the technology is implemented mostly for providing medium-term irrigation facilities with a considerable amount of low cost and ease of implementation. Government, however, now encourages farmers to use surface water instead of using groundwater to reduce pressure on the groundwater table. Especially, the situation is even more harsh in the Northwestern part of the country, which is severely agriculture

dependent but experiences a very little amount of rainfall. Thus, Rubber Dam technology cooperates to retain river water in the peak Summer Season, to support irrigation for producing Rabi Crops. It also assists in reducing the pressure on groundwater by making surface water available for irrigational purposes. As it facilitates irrigation making it cheaper in comparison with DTW/LLP, it furthermore makes agriculture more profitable affecting the socio-economic conditions of the farmers. Even like most other technologies, the Rubber Dam has also some negative impacts on the host communities which also needs to be investigated whether the technology is actually positively affecting the lives and livelihoods of locals or not. The study also wanted to assess the feasibility of the rubber dams, whether it is capable of making holistic good, and if the technology should be implemented in other regions as an adaptive structure against the water shortage during the dry season.

1.3 Significance of the Study

Mohonpur Rubber Dam's impact on irrigation and socioeconomic condition will be the primary areas of investigation. It will highlight the responses of beneficiary groups and affected groups and their opinions as well as suggestions. Overall dam performance, including agricultural and societal factors, will also be assessed. The results of the current study can help academics, environmentalists, and policymakers to know the roles of rubber dams in reducing the pressure on the groundwater table by encouraging farmers to use surface water which is readily available in Bangladesh. The research will reveal the extent of the cost that was supposed to be reduced for using surface water for irrigation purposes during the dry season.

The investigation will present scientific evidence of the effectiveness and limitations of the Mohonpur Rubber Dam, which may help policymakers to take more appropriate initiatives regarding this issue. Moreover, this study can be used further in relevant investigations. The inquiry also seeks to present recommendations and suggestions analyzing the research findings about the overall profitability of the rubber dam technology. Moreover, available resource suggests most of the study focuses on the agricultural aspects of the rubber dam technology, but no study was carried out in investigating the overall socioeconomic impacts of the dams. So, different aspects of agriculture and socioeconomic parameters from the Mohonpur Rubber Dam area can be explored through this study and this will also help in conducting the comparison.

1.4 Objectives of the Study

- To assess how farmers are benefited from irrigation facilities, how their groundwater dependency has been reduced, and to what extent their cost of agricultural production has been minimized,
- To Identify the socio-economic impacts of dam on the life and livelihood of people,
- To determine Command Area Efficiency, Water Use Efficiency, Yield Efficiency, and Benefit Cost Ratio**.**

1.5 Research Questions

1. How farmers are benefited in irrigation facilities and to what extent their cost of agricultural production has been minimized**?**
2. Does the introduction of rubber dam technology impact the livelihoods and well-being of the local communities residing in the affected areas? Are there changes in income generation, employment opportunities, and overall quality of life?
3. How does the implementation of rubber dams contribute to reducing the reliance on groundwater resources for irrigation? Are there observable trends in reduced groundwater extraction?
4. How is the performance of Mohonpur Rubber Dam in light of different calculations like Command Area Efficiency (CAE), Water Use Efficiency (WUE), Yield Efficiency (YE), and Benefit Cost Ratio (BCR)?

1.6 Limitations of the Study

The research also has several shortcomings. The major limitation of the study is that the study covered a specific selected site. This study could not consider or record the equal responses of female respondents as males. As the study focuses on agriculture and socioeconomic aspects, the family head was given priority because of their field-based information capabilities. The effective inclusion of community representatives in household surveys is also a serious challenge to the researcher. Only three villages close to the project area were selected and

studied due to budget and time limitations. If the whole command area could be studied, the research might produce comprehensive and holistic results which was not possible due to some limitations. Moreover, it became impossible to interview the local representatives as they were in government training programs in the Rangpur Division, which can also be considered as a limitation of the study.

1.7 Organization of the Thesis

This section provides a comprehensive summary of the individual chapters comprising this thesis.

1.7.1 Chapter 1: Introduction

The current chapter has many key components, including the contextual backdrop of the study, a concise statement of the topic under investigation, a discussion of the study's importance or reason, the formulation of research questions, the establishment of goals, and an acknowledgment of the study's limits.

1.7.2 Chapter 2: Literature Review

This chapter has provided a comprehensive review of the theoretical concepts, development history, methodology of the study, and existing literature. It has also explained the purpose of establishing rubber dams in different parts of the world and their benefits. The review part is organized from a global scale to a local scale. Firstly, the global impacts of rubber dams are presented, then subsequently it came to a local scale presenting the existing literature. As the impacts of rubber dams are multivarious ranging from agriculture to reducing pressure on groundwater table, different research articles were thoroughly reviewed and presented with their core research findings. In this section of the thesis, several factors were explained starting from the technical history of rubber dams to its widescale impacts on both agriculture and socioeconomic factors. Even, a portion of the section illustrated the calculations of various variables that are widely accepted among the scientific communities.

1.7.3 Chapter 3: Methodology

It has presented the overall research design of the current research. It has sequentially added data collection techniques, sampling techniques, site selection, data analysis tools, and

techniques and data representation methods, etc. It has given a brief theoretical description and formula of the techniques or methods used for data analysis in this chapter.

1.7.4 Chapter 4: Profile of the Study Area

This chapter has provided demographic, social, and spatial setting-related information about the study camps and its neighborhood. It has shown the location of the villages on the map and added maps of every village in their respective thana and district.

1.7.5 Chapter 5: Results and Discussion

This chapter illustrated research findings with relevant testimony. Even, several graphs were presented in order to provide an extensive idea about the findings. It also includes the correlation between different variables and identifies the underlying causes for the specific result. The chapter also presents the overview and perceptions of respondents.

1.7.6 Chapter 6: Conclusion and Recommendations

By using a synthesis of theoretical frameworks, empirical inquiries, and critical examination, this dissertation has elucidated the complex dynamics that exist between the effects of Rubber Dam on both agricultural practices and socioeconomic circumstances. The outcomes of the study highlighted the diverse characteristics of Rubber Dam and its wide-ranging ramifications in the field of Agriculture and other related applications. By conducting a thorough examination of the available literature, it was possible to consolidate the existing body of knowledge and identify areas that need more investigation. Following the empirical investigation, it was gained significant insights into the irrigation infrastructure used by the local population. Based on the discoveries presented within this dissertation, a number of suggestions arise that might provide direction for future research initiatives and practical implementations.

Chapter 02: Literature Review

2.1 Introduction

Literature review is an important section of a thesis. It serves as a foundation for the research by providing an overview of the existing knowledge and research in the chosen field of study. The fundamental objective of the literature review is to showcase the writer's comprehension of the topic at hand, identify gaps in current research, and highlight the relevance of their own work within the broader academic context. The introduction set the tone for the entire literature review and should engage the reader while clearly outlining the objectives of the review. The literature review is not merely a summary of existing studies but an analytical and critical assessment of the current body of knowledge. A well-crafted introduction will set the stage for a comprehensive and well-structured review, leading the reader to realize the significance of the research in the context of the broader academic conversation. The review included the opening statement, research relevance, and significance along with the objectives. The methodology part was also explained with sincerity as it provided a glimpse of techniques applied to fulfill the research objectives. Diligent endeavors have been made to compile the reports of many research related to these subject matters.

2.2 Rubber Dam

The proper handling of water resources is crucial to human survival. Dam infrastructure is the most widespread method to protect water resources for other uses. Dams are the most popular and effective water storage technology. These constructions may also provide irrigation, hydropower, flood control, water supply, pollution control, and groundwater recharge. Conventional dams might fail to accomplish many goals, particularly in smaller projects. The cost and time constraints are the main factors to be taken into account with traditional dams. Due to these inevitable issues, dams are being built using cheap materials. Rubber has emerged as a new material for creating water structures, notably dams and smaller dam-like structures. Rubber dams are used in big and small water projects because of their flexibility, environmental compatibility, simple design, efficient construction, safety, and stability. Rubber dams are easier to use and cheaper to operate than rigid constructions (Parish, 2016).

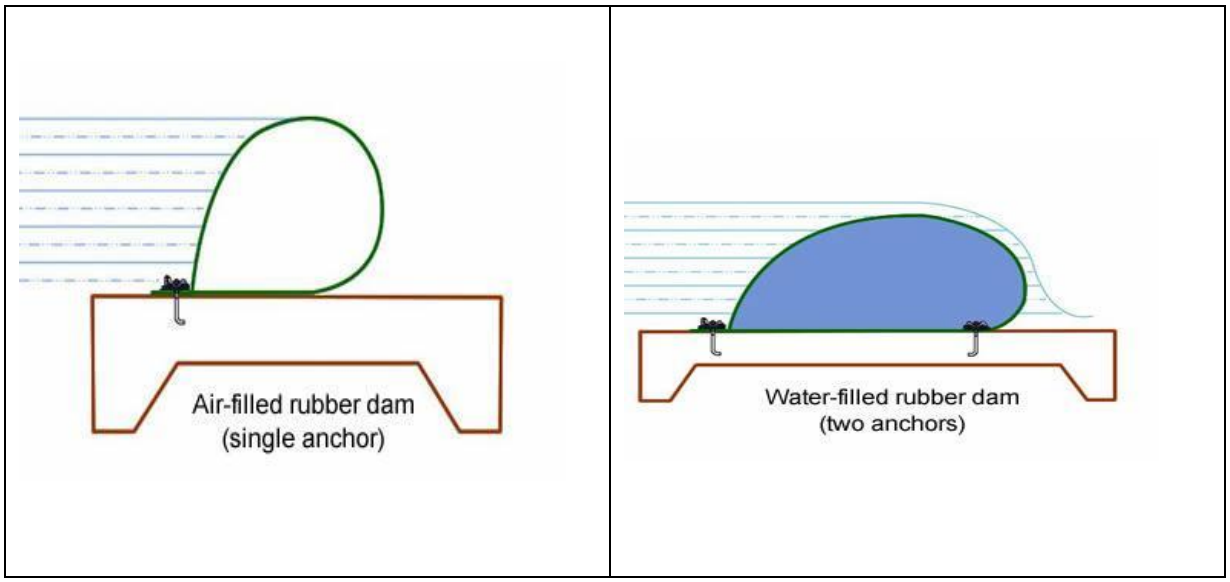
The evolution of rubber dams occurred throughout the 1950s, culminating in the first placement on the Los Angeles River in California. This installation aimed to facilitate groundwater recharge and mitigate flood occurrences. The first reservoir had been filled with a composite

of water and atmospheric gases (Plaut et al., 1998; Kahl and Ruell, 1989). Rubber dams have seen continuous technological developments since that period. The use of rubber dams for many applications is driven by their fundamental simplicity, adaptability, and well-established reliability (Zhang et al., 2002).

The rubber dam is an innovative hydraulic construction that emerged as a result of advancements in high-strength molecular synthetic materials. The constructions in question may be described as flexible elliptical forms composed of rubberized material. These forms are affixed to a solid concrete foundation and are inflated by the use of air, water, or a mix of both mediums (Shivhare et al., 2016). According to Jain (2017), the membrane is a composite material consisting of many layers of synthetic fibers, perhaps including rubberization on one or both surfaces and potentially supplemented with a plastic film coating. The textile material has notable flexibility while still displaying significant resistance properties. In order to raise the water level upstream, rubber dams are placed in channels, streams, and on top of weir crests and then inflated. It has the capacity to be filled with either water, air, or a combination of both. The current trajectory indicates a growing preference for the utilization of air-filled membranes due to their ability to be swiftly deflated or inflated, as well as their resilience in cold temperatures (Jain, 2017). The rubber sheet may be classified into single-layer, double-layer, and multi-layer configurations based on its height and strength characteristics. The fabric bag should possess water tolerance, water resistance, corrosion resistance, and durability under various atmospheric conditions. There is a growing propensity toward the utilization of air-filled membranes due to their ability to be promptly deflated or inflated, as well as their resilience to freezing temperatures.

The rubber dam project is an innovative hydraulic construction with four primary components. In order to function properly, the dam requires (i) a rubberized fabric dam body, (ii) a concrete foundation, (iii) a control room with mechanical and electrical components such as an air blower/water pump, and (iv) an inlet/outlet pipe system. Both single and double-line anchoring techniques are used to reliably fasten the dam's construction to the abutments and the concrete below (Tam et al., 2002). According to Nahar (2004), The first rubber dam in China was implemented in 1966, marking the beginning of China's proficiency in the domains of rubber dam design, production, and construction. Around the world, nations including Australia, Japan, Taiwan, Hong Kong, China, Indonesia, and Thailand are among the many that have built rubber dams. Depending on the filling media, rubber dams can be categorized into three

categories. These are air-filled dams, water-filled dams, and combined air and water-filled dam (Sharma et al., 2016).



Source: Zaoqiang Dacheng Rubber Co., Ltd, China.

Figure 1: Types of Rubber Dams

Topalian & Barron (2017) studied the application of rubber dams for hydropower generation. The study illustrated the historical advancement of rubber dam technology. It has been proposed that the notion of an inflated rubber dam was first patented almost seven decades ago by the renowned French engineer, M. Mesnager. In the mid-1950s, Norman Imbertson, an engineer employed by the Los Angeles Department of Water and Power, successfully developed and implemented the first functional rubber dam in Los Angeles, USA. Over the course of the next three decades, Japan emerged as the leading global producer of rubber dams, mostly due to the entry of Bridgestone, a prominent manufacturer of rubber products, into the market. Presently, around 6000 rubber dams are in active deployment globally, with Japan accounting for almost 4000 of these installations. Rubber dams have various forms of applications, including irrigation, groundwater replenishment, water retention, tidal and flood control, ecological rehabilitation, and hydropower generation.

2.3 Uses of Rubber Dam

Inflatable rubber dams are used to redirect water flow upstream over channels, streams, and weir crests. Dams and reservoirs can be built higher to generate more electricity, decrease water pollution, increase dam storage capacity, provide recreational opportunities like swimming and boating, and protect vulnerable coastlines from saltwater intrusion at high tide (Parish, 2016).

This sort of dam does not need a large workforce or sophisticated equipment to build or maintain. One of the greatest benefits of a rubber dam is the adaptability with which it may be used. Due to its portability, it may also be used as a makeshift dam while permanent structures are being built.

Shivhare et al., (2016) studied the prospects of rubber dams in the Indian scenario. It investigated the necessary benefits and uses of rubber dams. It revealed several benefits of rubber dams which include rubber dams for controlling floods, ideal and feasible water retention and conservation structure for easy irrigation during Summer, development of water resources and recharging the groundwater table for fresh and sustainable water supply, and to feed the physiography during the lean season. The study emphasized five feasible uses of rubber dam technology in India. These are:

i. Flood Controlling
ii. Irrigation
iii. Development of Water Resources
iv. Water Conservation and
v. Groundwater Recharge.

When the span of a gate is longer, using a rubber dam instead of steel becomes more cost-effective. They are easy to inflate and deflate and have a proven track record of reliability. Air-filled rubber dams are preferred over water-filled ones for various reasons. When selecting a suitable dam site, factors like geology, landforms, hydrology, weather, and hydraulics should be considered. The optimal location for the dam site is inside a linear segment of the river characterized by consistent and uninterrupted flow, as well as stable slopes of both the riverbed and banks. It is more advantageous to execute the development of civil infrastructure pertaining to the rubber dam during the dry season (Zheng et al., 2002). According to Hoque (2010), The extensive use of rubber dams encompasses the following applications:

• The dam serves as a flood control infrastructure,

• It retains water for irrigation purposes,

• It preserves water to recharge aquifers,

• It stores water to support fish production,

• It helps reduce or prevent the intrusion of saltwater into freshwater areas,

• It safeguards low-lying coastal regions from tidal flooding,

• It facilitates the passage of fish beyond diversion works by deflating the dam,

• It retains and separates sewage during flood events.

Rubber Dam projects in Bangladesh were first put into action in 1995 with the help of China's Institute of Water-resource and Hydropower (IWHR, 2020). This technology, known for its convenience and cost-effectiveness, was used for irrigation purposes (Rahman et al., 2016). Hasan & Kabir (2014) analyzed the agricultural viability, irrigation facilities, and water retaining capacity. Results suggested agriculture became profitable, irrigation facility was satisfactory and water retention capacity has increased. However, the benefits and uses of rubber dams are very satisfactory. It gained much popularity due to its easy construction facility, and low-cost availability. Developing or under-developed nations have adopted the technology widely for implementing small-scale irrigation projects.

2.4 Rubber Dam: Global and Regional Context

The structural factors and significance of rubber dams in India are studied. The study provides a comprehensive overview of the system, including its basic description, multiple configurations and kinds of operating principles, and a comparative comparison. The research identifies a rubber dam as a hydraulic construction that is comparatively modern in comparison to other structures such as sluice gates, weirs, and causeways. It is built using a mixture of high-strength fabric and rubber, resulting in the formation of a rubber bag. The rubber barrage is filled with air in order to provide inflation or deflation according to particular demands. The research further demonstrates that a rubber dam has several advantages, including simple hydraulic configuration, accelerated building process, exceptional seismic resilience, little water flow resistance during flood seasons, and other notable benefits. The integration of water management practices in urban areas has the potential to serve as a highly efficient mechanism for river water management, particularly in cities situated in close proximity to river banks. The inquiry brings an example of the Janjawati Rubber Dam (Kolte et al., 2017).

Tam (1998) investigated the problems and countermeasures of rubber dam technology in Hong Kong. The study revealed the rubber dam has the ability to be inflated and deflated, hence exhibiting dual functionality. In its inflated state, it assumes the role of an agricultural weir, functioning as a low-level dam. Conversely, when deflated, it operates as a flood mitigation device. It also discovered rubber dam issues including vandalism, flow-induced vibration, dam

inflation and deflation, and things transported upstream of the weir. The author suggested some countermeasures in order to get rid of these problems which are the Repair of inflatable dams, contractual arrangements, and contractual claims. In conclusion, the research suggested installing rubber dams in Hong Kong. A relatively new material in civil engineering became successful in Hong Kong.

The countries where agriculture is prevalent, a higher number of small dams made of rubber might help with the efficient management of natural resources and the conservation of water. Both the efficiency and cost-effectiveness of irrigation systems have been found to increase when rubber dams are used instead of traditional dams. Rubber dams, acting as check dams, may reduce the frequency and severity of floods, reduce dependency on the monsoons, increase water storage for controlled release, and ensure consistent distribution even during dry periods. This, in turn, encourages the efficient use and conservation of water resources (Rane et al., 2019). Rubber dams play a vital role in both urban and rural settings, acting as essential infrastructure for irrigation, industrial activities, and everyday use. The construction of dams has the potential to reduce the occurrence of floods and enhance the efficient allocation of water resources (Matkar, 2018).

Guo (2022) investigated the roles of rubber dams in flood fighting at the subway entrance in China and carried out a numerical analysis utilizing $FLAC^{2D}$ to study structural behavior. Additionally, laboratory model experiments were performed in order to validate the precision of the numerical model. The impacts of external floodwater head, inflated air pressure, and anchor placement on structural performance are also investigated by parametric models. Researchers determined that while the effect of expanded air pressure on the height of the rubber dam is not immediately obvious, it does greatly change the eventual height of the flood-fighting structure. The external floodwater head affects the dam's height in a nonlinear fashion. Dam flood resistance is significantly impacted by anchor depth. The tensile pressures felt by the dam are affected by the height of the incoming water. Additionally, air-inflated rubber dams made from thin-walled geomembrane material may still use the design chart (Ren et al., 2022).

The phenomenon of free-surface flows occurring above rubber dams is being studied in Taiwan. The work simulates free-surface flows through stiff circular-crested dams of different forms using the Volume of Fluid (VOF) technique and the Large Eddy Simulation (LES) model. The simulations indicated that although water depth H_2 has little effect on lift coefficients, it decreases the time-averaged drag coefficient. In addition, at a downstream depth of H_2/H_2 0.90,

the discharge coefficients of circular and elliptical dams agree with equations presented by previous research, as calculated from the simulated velocity profiles above the dam's crest. In contrast, a tear-shaped dam has a slightly higher discharge coefficient than a circular dam (Chu et al., 2021).

A study was conducted about the alteration in the potential of sediment phosphorus release along a series of rubber dams in a typical urban landscape river in China. Urban river landscaping uses rubber dams, which trap a lot of debris. Rich in phosphorus (P), sediments may eutrophicate rivers. The release of P from rubber dams is poorly understood. Sediment P release in a rubber-dammed urban river in northern China was evaluated using isotherm tests. The study found that fine sediment deposition in the first 4 dams resulted in a 76 percent sediment P release potential (percentage saturation of zero equilibrium P concentration, EPC_{sat}), whereas at the 4th dam, this value dropped to 67 percent. Between the fifth and thirty-first dams, fine sediment and water-soluble reactive P reduction drove EPC_{sat} up to 90 percent. In comparison to November, EPC_{sat} was significantly higher in April and August (p0.05). This dammed river's sediment P release seems to have been mostly regulated by biological processes and sediment particle size. Therefore, lowering P inputs and enhancing hydraulic conditions should be the main goals of management methods for rivers that have been dammed (Bao et al., 2020).

Zhang & Diao (2011) undertook a study regarding the discharge of Cascade rubber dams. This study examines the maximum discharge law for cascade rubber dams by calculating a sample of rubber dams' fall release and analyzing the acceleration, duration, and variables that affect the highest discharge. It concludes that cascade rubber dam downflow is endless and may be calculated by time intervals in engineering design. It also showed that the downstream rubber dam fall discharge was more affected by the upper cascading rubber dam fall discharge the shorter it was. Dam fall velocity due to rubber dams is the most important factor in water flow.

Research examining preliminary agricultural and hydrological data found that rubber dams may help water basins achieve sustainable crop production and increase crop and water productivity. Even though it has no environmental effect and can be set up and run cheaply (Sahoo et al., 2015). Maintenance is minimal save for filling (inflating) with water as needed. Again, 19 Baghamari farmers profited from irrigating their crops with stored water via the diversion irrigation canal near the rubber dam's upstream side. Farmers also used rubber dam water during rice blossoming, a vital development stage. After harvesting rice, the above

farmers' average production in Kharif in 2010 was 4.67 tons/ha-1, up from 2.87 in 2009, before the rubber dam was installed. The average productivity rises 62 percent (Jena et al., 2015).

Islam & Kumar (2015) evaluated the uses of Rubber Dams for Small Hydropower (SHP) in India. The study attempted to make a comparison between the traditional dams and rubber dams for water diversion in order to generate hydroelectricity from steep slopes. The paper tried to identify a suitable diversion structure that is less costly and sustainable for hydroelectricity generation. It has taken into consideration several aspects including economic and technical aspects. However, the research indicated that Indian rubber dams had lower life cycle costs than traditional weirs. The Life Cycle Cost (LCC) of imported rubber dams is three times that of Indian ones. It is the best option for small hydropower projects because of its low Life Cycle Cost, proven reliability, ease of operation, simple design, short building time, and structural simplicity.

The suitability of a rubber dam as a River Water Management Tool (RWMT) was examined. The study found that a rubber dam is cheaper, more flexible, and has fewer ecological and environmental impacts than a multi-purpose reservoir. The analysis also found that city water management might be an efficient instrument for river water management, particularly in cities near rivers (Yadav et al., 2015). An analysis was undertaken regarding the water flux and salinity gradients considering the effects of sea ice coverage and rubber dam technology in Liao River Estuary (LRE), China. The research found considerable variations throughout the year and seasons in water flows owing to river discharge variability and tidal oscillations. Research indicates that the LRS's net water flow into the sea is positive during rainy seasons and higher during ebb tides than flood tides. Tides caused the Liao River's discharge to be negative throughout the wet and typical seasons of the year. Compared to the Liujianfang Hydrometric Station (LHS), which is located in the LRE, the LRS provides a more accurate depiction of water flowing into the sea. The rubber dam and Panshan Sluice were discovered to have a considerable impact on downstream water flows (Hu et al., 2023).

The feasibility of constructing recreational dams between Ahvaz and Molasani for water sports and relaxation in Iran was studied. Based on Karoon River hydrologic and hydraulic parameters, dam sites and crest heights were established. After analyzing relevant factors and financial difficulties, the paper recommends setting up a rubber dam at Daghaghele Dam in the research region (Shoorab et al., 2017). A study was conducted regarding the impact of rubber dams on the development of water resources in urban areas in Gilan Province, Iran. Due to the

necessity of comprehensive water management in the province, rubber dams are predicted to enhance water resources in the province owing to their environmental friendliness, simplicity, quick design, and building time. The simplicity and convenience of operation, cost reduction, economic savings, and resolution of some hydraulic construction issues have made this kind of dam mostly used in both small and large-scale water projects. The study concludes to reduce the costs and solve some problems of hydraulic structures, the use of this type of dam in small and large water projects should be done properly (Ahmad et al., 2022).

The impacts of groundwater recharge from rubber dams on the hydrogeological environment in Luoyang Basin, China were examined. Based on the data collected from 2000 to 2012, there were no significant changes in pH levels. The content of NH4-N in the groundwater exhibited stability from 2000 to 2006, but had an upward trend from 2007 to 2012, with the most substantial rise reaching a magnitude of 0.2 mg/L. The concentration of NO3-N in the groundwater exhibited a decline between 2000 and 2006, followed by a rise starting in 2007. Notably, the most substantial increase occurred in 2012, reaching a maximum of 10 mg/L. The groundwater's total dissolved solids (TDS) exhibited a gradual decrease between 2000 and 2009. However, TDS levels had an upward trend after 2010, with the most significant rise seen near the southern bank of the Luohe River, reaching around 100 mg/L. The findings of the research indicate that the observed rise in NH4-N and NO3-N concentrations might potentially be attributed to fluctuations in groundwater levels. It is possible that the infiltration of nitrates into the groundwater occurred as a result of physical and chemical processes involving the silt clay in the aeration zone. Due to groundwater evaporation, TDS rose and soluble ions reached the unsaturated zone. The shallow groundwater brought the contamination closer to the aquifer's surface, increasing pollutant concentrations (Dong et al., 2014).

Another study was conducted regarding the prospect of establishing a rubber dam in the Shatt-al-Arab River, Iraq. The inquiry investigated the practicality of an inflatable rubber barrier, as a potential solution, in controlling the advancement of the salt advance generated from the intrusion of saltwater originating from the Arabian/Persian Gulf. A comparative analysis was conducted for evaluating the rubber dam in relation to other hydraulic structural regulators. The assessment of performance placed emphasis on three distinct domains, namely hydraulic, geotechnical, and economic aspects. The findings of the hydraulic study indicate that the water quality of the SAR is considerably influenced by tidal action. The geotechnical evaluation determined that the soil layers met the required standards. In the context of economic performance, the inflated rubber dam has been identified as a viable solution for the specific

absorption rate (SAR) issue, particularly when compared to other forms of regulators (Alkhafaji et al., 2022).

The strategic planning of rubber dams in Iran was evaluated using the SWOT (Strengths, Weaknesses, Opportunities, Threats) and SWOT-AHP (Analytical Hierarchy Process) methodologies (Ghorbani & Hamidifar, 2023). The study found that experts had a high level of accuracy in their responses, leading to a unanimous decision that the ST strategy should be implemented by responsible organizations. This involves using strengths to minimize threats and turn them into opportunities for the organization. The study also provided a list of practical and effective strategies based on the ST, SO, and WO approaches. Overall, it is crucial to utilize specialized staff, experienced companies, adequate budgets, and other resources to minimize damages and errors in all aspects of rubber dam projects. Pender & Berhanu (2002) conducted a study on the effects of small irrigation schemes in Tigray, a region in Northern Ethiopia. They concluded that these projects greatly improved the agriculture industry. The use of agricultural inputs, such as oxen, labor, fertilizer, and improved seeds, significantly increased. Additionally, crop production saw a significant improvement, with a reported 18 percent increase compared to rainfed areas.

Concept-based integration of project management and strategic management of rubber dam projects using the SWOT-AHP method were studied. The goal of this study is to improve the management of new, smaller-scale hydraulic facilities like rubber dams by incorporating PM standards and procedures into SM practices. SWOT analysis is used to identify the most critical internal and external factors in PM and organizational SM of Iranian rubber dam projects. Analytic hierarchy process (AHP) and SWOT-AHP methodologies examine and analyze the elements. The findings suggest that the organization's major approach is to eliminate vulnerability factors by using project opportunities, a WO strategy. A new "strategy matrix" is developed to prioritize and establish organizational strategies. The first three priorities are a blend of primary strategy possibilities including W_1 O_1, W_7 O_1, and W_9 O_1. The paper suggests monitoring organizational units, project resource management, and project stakeholder management for operational advantages. This study might be a prototype for sustainability management in impoverished nations (Skoulikaris et al., 2022).

A recent preliminary study regarding the design of a water-filled rubber dam as an efficient innovation in preventing tidal floods was conducted. It found that the choice of materials for water-filled rubber dams can impact pressure and flow stability. However, it can be difficult to

find domestic water-filled rubber dams in the market. To address this, geo-membrane material can be used as an appropriate technology for water-filled dam planning (Roehman et al., 2018). The Indian Council of Agricultural Research (ICAR) undertook comprehensive research to investigate the effects of rubber dams on agriculture in the state of Odisha, India. The study found that the disseminated rubber dams are capable of storing an additional 4000-100000 m^3 of water at any point in time. Furthermore, irrigated area has increased by 13-17 ha during the Kharif season. Average productivity enhanced by 22-34 percent while cropping intensity increased by 31 percent. Monetary calculations expressed a clear glimpse over the gross return ranging up to Rs. 44000 per ha and the benefit-cost ratio result was 2.30 which is really good condition. Rice production has increased potentially (Indian Council of Agricultural Research, 2018).

Tam, P. W. M. (1997) undertook an investigation regarding the uses of rubber dams as a means of mitigating floods in the region of Hong Kong. According to the research, the effectiveness of dams in reducing the risk of flooding lies in their ability to inflate and deflate. When a dam is inflated, it acts as a low-level dam for agricultural purposes. However, when the dam is deflated, it serves as a flood mitigation tool. In Hong Kong, rivers overflowed during severe rainstorms, causing flooding in various parts of the region. The rubber dams are versatile and can automatically deflate when the water level reaches a certain point, reducing the risk of flooding. These dams are particularly useful for the local farming communities in Hong Kong (Paul, 1997).

In agriculture, weirs are commonly used to increase water storage and divert water into irrigation canals. They may also boost river water levels, reducing the net positive suction head of irrigation river abstraction pumps. River water abstraction for irrigation is difficult because to high alluvial and low water levels. Rivers benefit from inflatable weirs' versatility. Weirs are installed in river channels to create storage points and provide enough water for agriculture. This intervention has been successful but also affects the watercourse as flowing water is slowed, impacting the environment and river flow patterns (Tagwi, 2015).

The prospects that the rubber dam provides in recharging the groundwater aquifer cannot be ignored as the structure already proved its necessity in the case. The Santa Ana River Basin in Orange County captures roughly 25 million cubic meters of stormwater annually to provide water for 100,000 people. The aforementioned objective is accomplished by using percolation ponds that span over an area exceeding 1,500 acres next to the river. The basins are managed

inside the river system itself, as well as at various off-river sites, using inflatable rubber dam technology for the purposes of retention and recharging. The use of inflatable rubber dams has been shown to effectively enhance the diversion capacity of off-river basins. This approach would enable the containment of greater volumes of water and mitigate the labor and time-intensive process of replacing sand levees, hence facilitating the provision of water supplies to a population of two million inhabitants (Markus et al., 1996).

2.5 Rubber Dam: Local Context

Saleh & Mondal (2001) undertook a comprehensive assessment to analyze the impacts of the Bakkhali and Idgaon rubber dam initiatives in Bangladesh. The researchers conducted field surveys to examine the hydrological, agronomic, and socio-economic dimensions of the dam within the area. The study area's evaluation involved the use of standard indicators grouped into three categories: hydraulic, agricultural, and socioeconomic. During the 1998-99 irrigation season, field measurements and a questionnaire survey quantified and qualitatively assessed these factors. The Bakkali project had enough water supply, while the Idgaon project did not. In all projects, feasibility assessments projected quantities, resulting in poor water supply. Due to superior management and deficit irrigation, the Idgaon project used 28 percent less water than Bakkhali. Due to goal command area overestimation, both projects had low irrigated area performance. However, agricultural output and water productivity were adequate. Socio-economic metrics suggested both rubber dam projects were profitable. A study was conducted regarding a comparative analysis to assess the economic roles of rubber dam technology in irrigation development. The study specifically focused on evaluating the capital operation and maintenance (O&M) expenses associated with various irrigation methods (Mondol et al., 2002).

The roles of rubber dams in Bangladesh harnessing surface water for farmers to irrigate at a lesser cost were evaluated. The extreme uses of groundwater for various purposes especially for irrigation led to the depletion of the groundwater table. In order to facilitate irrigation during the summer season, it is crucial making use of available surface water and harness it. Additionally, the recent discovery of arsenic contamination in some areas of the country underscores the importance of conserving surface water. Not only is surface water of higher quality, but it is also more cost-effective. Farmers in Bangladesh should prioritize using surface water for irrigation instead of groundwater due to the flat landscape that does not allow for reservoir development. Rubber Dams store water in small and medium river channels for

winter-summer agriculture. Rubber Dams increase irrigation coverage and provide a constant water supply during dry winter/summer seasons. This increases agricultural productivity by 18500 tons of rice annually. The availability of water during dry winter/summer days has increased winter vegetable production in high and homestead locations (Khan et al., 2004).

Reducing poverty in Bangladesh is a complex and challenging task. One solution to providing affordable irrigation water to rural farmers, many of whom are struggling financially, is through the use of rubber dams. These dams specifically benefit small and marginal farmers who own land between 0.20-1.00 hectares. The cost of implementing rubber dams is approximately half the cost of irrigation through groundwater (Khan et al., 2004). Saleh (2008) examined Gazipur District's Kawraid River Rubber Dam Project (KRRDP) in the 2000-01 Boro Season. It examined how the KRRDP affected agricultural performance and poverty. The research examined the results of the experiment with and without intervention using the 2000-01 Boro season as a baseline and 2006-07 as the current year. Poverty was self-assessed, whereas agricultural success was examined through indicators. The average Boro rice yield per hectare in the WP region was 30 percent greater than the base year, whereas it was only 7 percent higher in the WOP area. In the current year, WP net income (Tk./ha) was 180 percent greater, and WOP 3.6 percent higher than the base year. The KRRDP reduced poverty by 4.5 percent, and for every percentage increase in irrigated land, WP poverty decreased by 0.2 percent. Multiple regression findings also showed that Boro rice farming revenue reduced WP poverty. KRRDP's irrigation intervention boosted farming and income, reducing poverty and improving living conditions for rubber dam beneficiaries.

In a study conducted by Hoque (2010), the functioning of Pekua Rubber Dam in Cox's Bazar District was examined. The rubber dam built in 2004 is functioning well. It has increased irrigated land, yield, income, and employment opportunities while improving the local environment. The construction was timely, cost-effective, and simple. An investigation on the operation assessment of the rubber dam project for irrigation facilities in Bangladesh was undertaken. The study evaluated a rubber dam irrigation project's technical parameters. Low-lift Pumps (LLP) were used during dry seasons to reduce water crises. The project saw an average Command Area Efficiency of 63.91 percent, an average Management Performance Ratio of 0.028 percent, average Yield Efficiency was 41.8 kg m^{-3}, and average Benefit Cost Ratio (BCR) of 1.34 percent. Constraints were identified, including a lack of electricity, poor management, and limited farmer participation (Sarkar et al., 2011).

A study evaluated the Natore Rubber Dam's impact on agriculture and its feasibility on the Mohananda River. Hydraulic, agricultural, and socio-economic aspects were assessed, showing that water supply was available, irrigated areas were satisfactory, and the project was financially viable for farmers. Rubber Dam technology could be an effective alternative to groundwater usage, with potential benefits to the economy. A comparative analysis was conducted to determine its viability in irrigation development (Hasan & Kabir, 2014). Upon conducting an assessment of the Buraghat Rubber Dam project, it was noted that scheme-1 exhibited a Command Area Efficiency (CAE) of 30.71 percent, whereas scheme-2 showed a CAE of 27.14 percent, so suggesting an average level of performance. The Management Performance Ratio (MPR) was 0.019 and 0.021 for scheme-1 and scheme-2 respectively. Both schemes had a Water Use Efficiency (WUE) of 32 kg m^3 and 37 kg m^3. The Benefit Cost Ratio (BCR) for both schemes was 1.50 and 1.52, respectively, which is considered reasonable. The study identified several performance constraints that need to be addressed to achieve the desired outcomes for the Buraghat Rubber Dam irrigation project (Rahman and Hasan, 2016).

A study assessed the efficacy of the Chowmohani Rubber Dam in the Habiganj District, with the aim of enhancing the socioeconomic conditions in the region. The analysis looked at income, job opportunities, agriculture, fish production, CAE, MPR, and BCR. Results showed significant improvements in income, jobs, agriculture, and fish production. CAE for schemes 1 and 2 was below standard, but overall, the rubber dam project was beneficial for the area's socio-economic conditions and farmer profitability (Singha et al., 2019). A comparative analysis was undertaken to examine the Menongchara and Buraghat rubber dam projects in the Mymensingh District of Bangladesh. This study compared two rubber dam projects, Menongchara and Buraghat, based on technical, hydraulic, agricultural, environmental, and socio-economic indicators. Results showed Buraghat performed better in actual irrigated areas, but both had similar irrigation efficiency and water productivity. Both projects had positive impacts but with a few technical problems. The management committee of Buraghat was more active, and it received financial and technical support, while Menongchara did not. Overall, both projects are performing well. Both projects had a positive impact on fisheries, vegetation, livelihood, and wildlife (Ahmed et al., 2020).

A separate investigation was undertaken to examine the effects of the anticipated implementation of rubber dam assisting surface water irrigation on the surrounding groundwater in the Chapai Nawabganj area of Bangladesh. Bangladesh has a plan to reduce its usage of groundwater for irrigation and instead use more surface water. In order to

accomplish this objective, the Bangladesh Water Development Board (BWDB) is putting out a proposition for the construction of a rubber dam on the Mohananda River, situated in the Chapai Nawabganj district. After conducting river-groundwater modeling, it was discovered that the decline in groundwater has slowed to 50 millimeters yearly in the irrigation zone. As a result of using more surface water, groundwater levels will have risen over 141 km^2 and 242 km^2 in 2029. This transition has effectively reduced the rate of groundwater decline, particularly in the irrigation zone (Paul & Hasan, 2021).

2.6 Performance Constraints of Rubber Dams

A study was undertaken regarding the phenomenon of saltwater intrusion resulting from dam collapse in the Cimanuk River Estuary in Indonesia. The present study indicates that previous research on the Cimanuk River has been limited, with just two studies conducted (Sukardjo et al., 2014; Yuanita and Tingsanchali, 2008). These studies mostly focused on investigating the process of delta formation. However, no research has been conducted specifically on the Cimanuk River itself. The dam's breakdown resulted in the intrusion of saltwater into the river. The collapse of three rubber dams resulted in a subsequent scarcity of water in the downstream area. Two factors contributing to the dam collapse were identified: the substandard quality of the rubber and the insufficient capacity of the reservoir storage (Trinugroho et al., 2020). A study suggested that seawater entered the river from downstream to upstream after the dam failure. Saltwater infiltrated the dam across 20 miles. Seawater intrusion affects household and agricultural freshwater supplies. The Waledan Dam was built to provide water to the northern shore and protect it from seawater. The dam structure was made from high-strength cotton and rubber between 2011 and 2013. The study analyzed Cimanuk River seawater intrusion after a rubber dam breach. Higher freshwater output reduces incursions. Seawater incursion is severe during High Water Slack, particularly with insufficient freshwater. The results suggest repairing the rubber dam to reduce saline incursion (Dewi et al., 2016).

An investigation was conducted on the urban landscape water in Shandong Province of China by Semi-quantitative method. A system evaluates landscape water projects in various areas and ranks them based on their development degree. The natural, ecological, and social characteristics of a project impact its development, making it crucial to consider these factors for sustainable development. Mentioning the critical effects on the development degree of landscape water projects by Xiaobudong Rubber Dam of Linyi (Deng et al., 2015).

In a comparative analysis conducted on the Menongcchara and Buraghat Rubber Dam Projects in Mymensingh, the authors observed many restrictions. The identified issues are to the impediment of achieving the maximum use of water resources. The Buraghat and Menongchara projects have presented a number of challenges for the residents of the area. Several issues may be identified in the context of water management. Firstly, there is an unequal distribution of water in the region of Buraghat. Secondly, the absence of effective project management is evident in Menongchara. Lastly, inadequate maintenance of the canal system is seen. Resolving these problems would result in greater benefits from the rubber dam projects. Both projects also have some technical issues that need to be addressed (Ahmed et al., 2020).

The performance review of the Buraghat Rubber Dam Project in irrigation advancement at Haluaghat, Mymensingh has also shown comparable challenges. The dam expressed performance constraints in Command Area Efficiency which have been identified as substandard. According to the study, the BRDP's Command area efficiency is insufficient. The relatively low Command Area Efficiency (CAE) assessment suggests that there is a considerable amount of land that might be effectively irrigated with an improvement of management strategies. Even, authors have made several recommendations in order to increase training facilities, and electricity supply, establish more canals, formulate suitable crop calendars, and crop diversifications (Rahman & Hasan, 2016).

2.7 Conclusion

This literature review provided a comprehensive analysis of the rubber dam's significance and applications from a global scale to a local scale. Throughout the chapter, the multifaceted benefits, environmental impacts, economic considerations, and the perspectives of various stakeholders involved in its implementation were discussed. This chapter explores the various applications, benefits, and drawbacks of rubber dams from a global perspective. It emphasizes the significance of using rubber dams as a sustainable and innovative solution. On a global scale, rubber dam technology has emerged as a promising sustainable solution. Its ability to control water flow, manage floods, and mitigate the effects of droughts has been evident in various countries across the world.

Moving to a regional and national scale, we discovered that the implementation of rubber dams has encountered various challenges, including performance constraints, policy barriers, several kinds of impacts. However, the success stories from different regions are demonstrated that proactive engagement with local communities, stakeholders, and policymakers is crucial in

overcoming these hurdles and fostering the adoption of rubber dams on a larger scale. Zooming into the local scale, the review highlighted the importance of considering local community needs in the design and deployment of rubber dams with sustainable outlooks. Local case studies showed how a tailored approach can enhance the effectiveness and efficiency of the technology, yielding multiple benefits for communities, agriculture, and ecosystems. For maximizing advantages and limiting negatives, site-specific planning, environmental assessments, and stakeholder involvement are essential. Their limits are discussed in a chapter along with literature failures and author-supported solutions.

Chapter 03: Methodology

3.1 General

The methodology chapter is a critical section in any research paper, serving as the backbone of the study's design and execution. The researcher's strategy for addressing the research questions and achieving the study's goals is explicated in this text. This chapter presents a full exposition of the study design, data collection methods, the participants or subjects engaged, sampling strategies, basic information pertaining to analytical instruments and software, and the analytical techniques utilized. The goal of this chapter is to establish the reliability, validity, and rigor of the research, ensuring that the results obtained are credible and trustworthy. The establishment of a well-organized and rigorous technique is crucial in order to guarantee the legitimacy and dependability of the study outcomes. Moreover, the general section of the methodology chapter serves as a concise introduction, providing readers with an overview of the research design, data collection methods, and other key aspects of the study's methodology. It acts as a guide, orienting readers to the more detailed and in-depth information that follows in subsequent sections.

3.2 Research Design

Research design is the blueprint that outlines the systematic plan and structure of a research study. It serves as the foundation on which the entire research process is built, guiding researchers in their quest to address specific research questions or objectives. A well-constructed research design ensures that the study is valid, reliable, and capable of generating meaningful and trustworthy results. The present study used a descriptive research approach to assess the agricultural and socioeconomic effects of the Mohonpur Rubber Dam, as well as its overall performance. Additionally, the study incorporated both quantitative and qualitative research designs. The aim of the quantitative research approach was to investigate the associations, connections, and causal interactions between variables. It sincerely examined and presented the profile of the local stakeholders in different analytical ways, including analysis of their income and expenses, professional dynamics, agricultural benefits, and other socioeconomic variables. It also involved the collection of structured data through surveys, experiments, or observations and the subsequent application of statistical methods to analyze and interpret the data. Different variables were thoroughly examined to illustrate the performance of the Mohonpur Rubber Dam. While qualitative research aims to understand the

perceptions of beneficiary groups, including the complexities of their behavior and experiences derived from the rubber dam operation. It involved the collection of non-numerical data through methods such as interviews, focus groups discussion, observations, and Key Informant Interviews. The data are then analyzed to identify themes, patterns, and narratives that provide rich insights into the research topic.

3.3 Data Sources

To conduct the study both primary and secondary sources of data were used. A field survey was conducted in order to collect primary data in the form of a semi-structured questionnaire. The respondents of the study area answered the questions asked by the researcher and the head of the household was chosen carefully for presenting actual information about agriculture and socioeconomic status. To fulfill the research objectives secondary information was thoroughly reviewed. To gather information for the study, I reviewed relevant literature from a variety of sources, including online materials and published documents. The data collection process included a wide range of sources.

3.4 Data Collection Techniques

Data collection is a fundamental step in the research and analysis process, enabling the acquisition of valuable information from various sources to gain insights and make informed decisions. The selection of data-collecting instruments and methodologies is dependent on the characteristics of the study, the specific data searched for, and the resources at hand. The data collection procedure included the acquisition of primary and secondary sources. To start, a compilation of indicators was identified. Based on these variables, a questionnaire was designed in order to collect primary data. Additionally, secondary data was gathered in accordance with the aforementioned indications. The methods for acquiring primary and secondary data are detailed in the following sections.

3.5 Primary Data and Information Collection

The fieldwork for the study was conducted in a single phase from June 6, 2023, to June 13, 2023.

3.5.1 Semi-structured Questionnaire for the Households

The collection of primary data and information was conducted by administering semi-structured open-ended questionnaires to a specific sample of residences. These households are

the beneficiary groups of the rubber dam project. In other words, the people surveyed for the study are the inhabitants of the villages located close to the dam. They are in a sense the stakeholders. People get benefits in the form of irrigation facilities, and fishing opportunities, while riverbank erosion also became apparent in the study area. So, people became very helpless losing their inherited property to the river. The participants were chosen using a random selection technique. The use of face-to-face personal interviews offers researchers an appealing option to get comprehensive and detailed information directly from the respondents. The conversations undertaken yielded valuable insights on the effects of rubber dams on several aspects, including agriculture, irrigation infrastructure, the social profile of the respondents, and the extent of these influences within their socioeconomic sphere. The interview also includes the probable solution to the current problems experienced by the local stakeholder and solutions.

3.5.2 Pre-testing of the Questionnaire

Pre-testing a questionnaire is a crucial step in the process of survey research and questionnaire development. It involves administering the draft questionnaire to a small sample of the target population before the actual data collection to identify and rectify any potential issues with the instrument. The fundamental objective of doing pre-testing is to ascertain the clarity, reliability, and validity of the questionnaire, hence enhancing the overall quality and accuracy of the gathered data. The household interviews required approximately 15-20 minutes to conduct. However, At the beginning day, five interviews were taken as a sample of validating questionnaires. Moreover, the literature review was studied thoroughly in order to develop the questionnaire properly. The preceding methodology was used to appropriately document the perspectives of homeowners on the effects of the Rubber Dam Project within the framework of their agricultural and socioeconomic circumstances.

3.5.3 Sample Size Determination for Household Survey

Sampling refers to the deliberate and systematic act, process, or method of choosing a proper sample, which is a representative subset of a larger population. The primary objective of sampling is to gather information on the parameters or features of the whole population (Verma et al., 2017). Sampling strategies in research provide two primary advantages: expedited data collecting and decreased costs (Cochran, 1977). The objective of the sampling procedure is to carefully choose a suitable population and thereafter secure their involvement in order to get precise data at the field level (Blair, 2017). The houses included in the study were chosen by a random sampling method from the population residing in the designated villages of Dinajpur Sadar Upazila and Chirirbandar Upazila, located in the Dinajpur District of Bangladesh. The

calculation of the sample size was determined using the method proposed by Yamane (1967), taking into account the total number of households within the research area's villages and aiming for a precision level of seven percent.

$$n = N/ (1 + N \times e^2)$$

In the case of this study,
n represents the sample size (number of households chosen to interview);
N represents the in-total households in the study areas;
e represents level of error.

To assure the attainment of precise and reliable outcomes, a rigorous sample size determination was carried out, using a confidence level of 95% and a precision level of 7%. The population size in the selected localities required a recommended sample size of 135. According to Kish (1965), it is suggested that a field survey may be effectively carried out by engaging a sample size ranging from 30 to 200 respondents. The study successfully achieved its purpose in terms of recruiting an adequate number of respondents.

3.5.4 Focus Group Discussion (FGD)

Focus group discussions (FGDs) are a qualitative research methodology that bears considerable importance in the exploration of individuals' views, attitudes, opinions, and experiences pertaining to a certain subject matter. Focus Group Discussions (FGDs) facilitate in-depth exploration of human ideas and emotions by creating a controlled and inclusive setting where a limited number of participants are brought together. Under the guidance of a proficient facilitator, individuals engage in a methodical but flexible dialogue, providing valuable perspectives on their cognitive and emotional experiences. The dialogues often center on open-ended inquiries that enable individuals to exchange narratives, viewpoints, and responses, therefore elucidating the intricate aspects of the study topic. Multiple benefits of FGD include interactive and contextual exploration, rich data collection, group dynamics, social influence, exploring unconscious attitudes, etc. Three FGDs were conducted for the study in three villages. One FGD was conducted with the farmers in Parameshwarpur village, whereas in Dhakail village women were taken as participants for conducting another FGD. Another FGD was conducted in Bhabki village regarding the irrigation facilities and the overall impacts of the Mohonpur Rubber Dam.

3.5.5 Key Informant Interview (KII)

Key Informant Interviews (KIIs) are a qualitative research methodology that has significant importance in the collection of useful insights from persons who possess specialized knowledge, competence, or experience in a certain domain. The interviews often used in this context are semi-structured in nature, which permits a certain degree of freedom in investigating the intricacies of the topic, while yet adhering to a standardized framework. Researchers often develop a series of open-ended questions. However, the dialogue may naturally evolve to include unforeseen perspectives and findings. Key informants play a crucial role in research by providing primary information and contextual expertise, hence enhancing the richness of the study results. However, to fulfill the objectives of the study three KIIs were undertaken. Dam Operator, a Madrasa Assistant Superintendent of A.K.M. Lafijuddin Chowdhury Dhakail Madrasa, and a retired Headteacher of Dhakail Government Primary School were interviewed extensively as three KIIs for the research.

3.6 Secondary Data and Information Collection

The research methodology of secondary data collecting involves the acquisition and use of pre-existing data that has been previously gathered by other researchers, organizations, or entities for objectives unrelated to the present study. The platform functions as a significant tool for scholars, providing them access to a diverse array of information without necessitating the doing of primary data collecting. Secondary data may be obtained from a diverse range of public and commercial sources, including government organizations, research institutes, databases, published literature, and internet archives. The collection of secondary sources of information included gathering data from both published and unpublished research materials that were relevant to the subject of inquiry. Books, academic articles, research reports, government reports, NGO documents, conference proceedings, locally published reports, maps, and official websites were all used as sources.

3.7 Data Analysis

Data analysis is a critical phase in the research process that involves transforming raw data into meaningful information to draw conclusions, make informed decisions, and address research objectives. It is a systematic and organized approach that encompasses various techniques to examine, clean, interpret, and present data in a way that facilitates understanding and drives actionable insights. The main and secondary data were analyzed using the indicators and

questions outlined in the questionnaire. The examination of the data included the use of basic descriptive statistics, such as frequency and percentage distribution.

3.7.1 Weighted Average Index

The primary statistical method used in this study was the weighted average index (WAI), which was implemented using the scaling strategy as described (Khongsatjaviwat & Routray, 2015). According to Pal & Ghosh (2017), a single index for all replies was generated by integrating option weights and question weights. The checklist scores were then analyzed, and a weighted average was obtained for the questionnaire. The degree of relevance of each indicator was assessed using the WAI, which is regarded as a rapid tool for evaluating variations in respondent perceptions (Pakzad, Osmond, & Corkery, 2016). The use of this method facilitated the transformation of ordinal data into scale data, enabling the examination of respondents' views and opinions on the effects of rubber dam implementation on agricultural and socioeconomic circumstances.

The Weighted Average Index (WAI) for each indicator was computed by multiplying the response numbers for each indicator by a weighted value ranging from 0 to 1, summing the results, and then dividing by the total number of replies (Pakzad et al., 2016). This yielded a comprehensive weighted average score for each specific indication. The computation method for the Work Ability Index (WAI) (Ha & Thang, 2017):

$$WAI = \Sigma S_i \, f_i / N$$

The weighted average index (WAI) is a value that falls within the range of 0 to 1. It is calculated using the scale value (S) given to each priority, the frequency (f_i) of respondents from households, and the total number of observations (N). The indices were constructed with consideration of the social scale, with each measure assigned a value ranging from 0 to 1. The description of each index type is as follows.

Perception Index

Household heads were surveyed to determine how they felt about the local government's handling of climate change. There are five distinct stages:

Table 1: Perception Index Stages

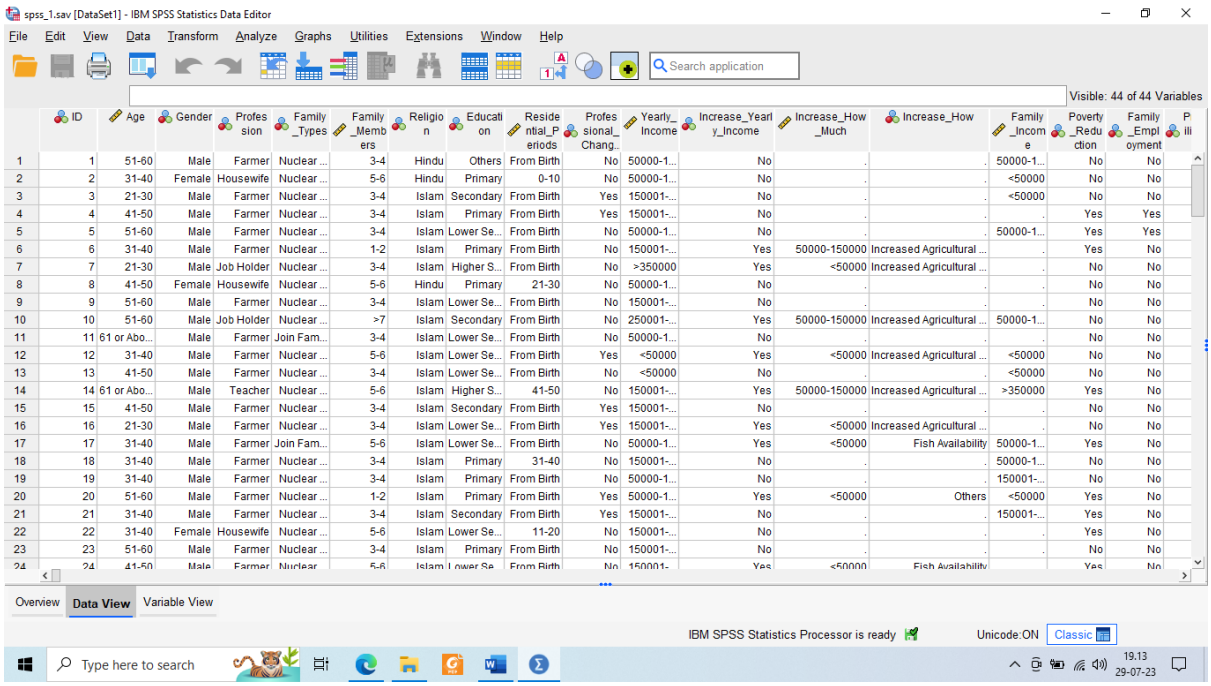
Categories	Very Satisfactory	Satisfactory	Neutral	Unsatisfactory	Very Unsatisfactory
Scale	1	0.8	0.6	0.4	0.2

Satisfaction Index

Here is the formula for determining the satisfaction index:

$$WAI = (1.00 \cdot f_1 + 0.8 \cdot f_2 + 0.6 \cdot f_3 + 0.4 \cdot f_4 + 0.2 \cdot f_5) / N$$

WAI is the weighted average index ($0 \leq WAI \leq 1$); The variable f_1 represents the frequency of the first option on the scale, whereas f_2 represents the frequency of the second choice, f_3 represents the frequency of the third choice, f_4 represents the frequency of the fourth choice, and f_5 represents the frequency of the fifth choice. The overall assessment (OA) is derived by computing the mean of the weighted average index (WAI) values (Nooriafshar, Williams, & Maraseni, 2004)



Source: IBM SPSS 9.0 Software

Photo 1: Data Analysis Using IBM SPSS Statistics Software

3.7.2 Quantitative Data Analysis

To evaluate the impacts of the Rubber Dam on agriculture and socioeconomic variables, quantitative data collected through household surveys were analyzed using IBM SPSS Statistics 29 software. The raw data was summarized using a spreadsheet (Excel) and simple statistical techniques were used to create graphical representations that aided in interpreting the

3.7.3 Correlation Matrix Analysis

Correlation matrix analysis is a statistical methodology used to investigate the associations among various variables. The process involves the computation and analysis of correlation coefficients among pairs of variables, often shown in the format of a matrix. The aforementioned methodology is extensively used across diverse disciplines such as statistics, finance, social sciences, and data analysis, with the aim of elucidating patterns, connections, and insights inherent in datasets. Correlation among several variables which are the increase of yearly income, family member's income, family employment, communication improvement, increased crop production, reduction in irrigation cost, fish availability, and poverty reduction are analyzed through the correlation matrix analysis using SPSS software 29.

3.8 Theoretical Calculations

The theoretical considerations were reviewed by Molden and Gates (1990) and Molden et al., (1998).

3.8.1 Command Area Efficiency (CAE)

The percentage expression of the ratio between the actual command area and the prospective command area is referred to as the command area ratio.

$$\text{Command Area Efficiency} = \frac{\text{Actual Command Area}}{\text{Potential Command Area}} \times 100$$

3.8.2 Irrigation Efficiency (IE)

The measurement of irrigation efficiency is also a significant indication. The crop water productivity refers to the ratio between the quantity of water utilized by the crop and the quantity of water provided by irrigation and is precisely described as such.

$$\text{Irrigation Eficiency} = \frac{\text{Total demand of Water}}{\text{Total supply of Water}} \times 100$$

3.8.3 Benefit-Cost ratio (BCR)

It is the ratio of gross return to total cost.

$$\text{Benefit} - \text{Cost Ratio} = \frac{\text{Gross Return}}{\text{Total Cost}}$$

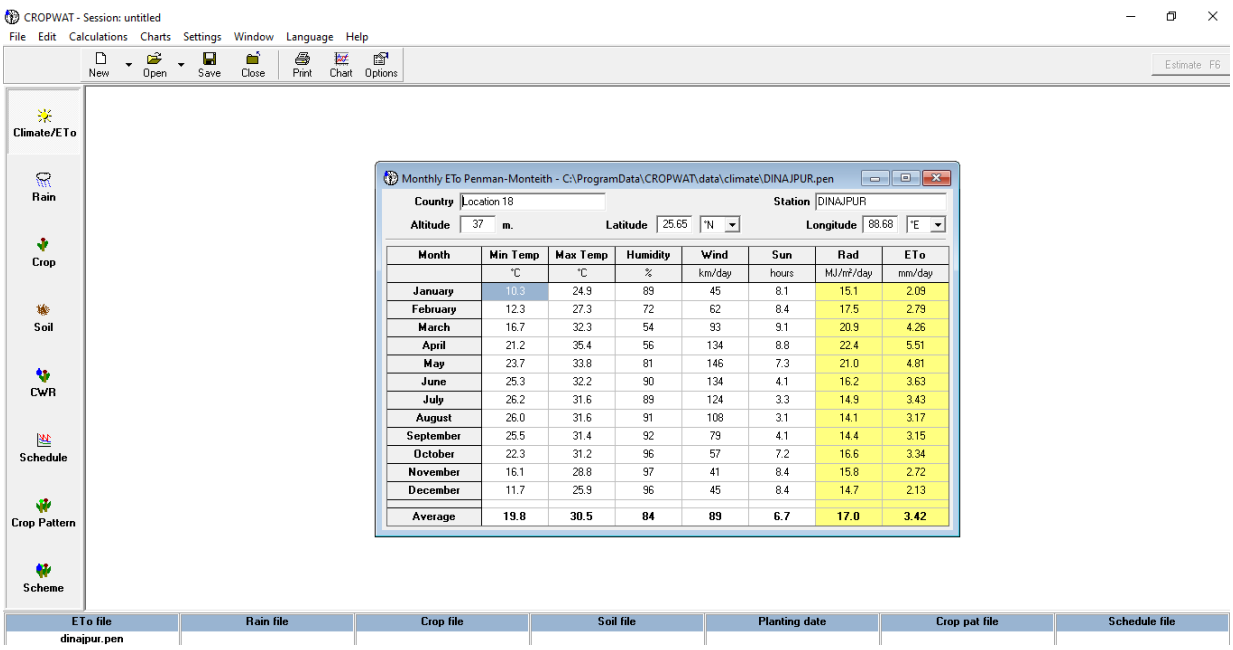
The total cost of agricultural production encompasses several components such as seed expenses, fertilizer costs, plowing expenditures, labor wages, pesticide investments, tax obligations, and organizational upkeep fees, all measured in the currency of taka per hectare.

The gross return includes the monetary value of crops and straws, measured in taka per hectare.

3.8.4 Yield Efficiency (YE)

Yield efficiency may be defined as the proportion of the actual yield achieved in relation to the intended yield.

$$\text{Yield Efficiency} = \frac{\text{Actual Yield}}{\text{Target Yield}}$$



Source: FAO CROPWAT 8.0 Irrigation Calculation Software

Photo 2: Irrigation Calculating Software developed by FAO

Chapter 04: Profile of the Study Area

4.1 Introduction

This chapter aims to provide a concise overview of the study areas, including their location, demographics, and sociological characteristics of the communities in the surrounding areas, as well as their spatial characteristics. In order to comprehensively examine the impacts of the rubber dam on agricultural and socioeconomic status, it is essential to have an extensive knowledge of the historical context surrounding the creation of the dam. Although there may be limited information available to accurately depict the situation, the research attempts to provide readers with a basic understanding, sometimes using highly descriptive language.

4.2 Selection of the Site

According to Hasan and Kabir (2014), insufficient winter rainfall poses a significant challenge for irrigation in Bangladesh. To address this issue, the Bangladesh Agricultural Research Council (BARC) has been conducting research since 1974. In 1994-95, the BIC (Beijing IWHR Corporation) initiated Rubber Dam projects in Bangladesh. These projects have proven to be highly convenient and effective for both winter irrigation and crop cultivation. The primary objective of the National Water Plan Project-II (MPO, 1991) was to establish an irrigation system that uses pumps to harness surface water from the main river for agricultural purposes. In order to achieve this objective, a range of water control structures such as barrages, regulators, drainage sluices, earthen dams, weirs, inlets, outlets, and inflatable rubber dams were used. Since then, LGED, BWDB, and BADC have implemented numerous rubber dam projects in Bangladesh to retain water for irrigation.

The implementation of these projects was undertaken with the objective of fulfilling the government's intention to transition from groundwater to surface water irrigation (Paul & Hasan, 2021). Examining the viability and impact of Rubber dams in the context of agriculture is a significant and challenging endeavor. Nevertheless, there came a need to conduct an investigation into the effects of the Mohonpur Rubber Dam project on both the agricultural sector and the social conditions of the local population. Thus, the Mohonpur Rubber Dam project was chosen as the subject of the study, which is located between two upazilas, Dinajpur Sadar and Chirirbandar, and was inaugurated on October 22, 2013 (TBS, 2022).

Table 2: Population of the Study Villages

Study Villages	Total Households
Parameshwarpur	58
Bhabki	101
Dhakail	248

Source: BBS, 2011

4.3 General Information of Upazilas

To understand the research background and objectives clearly and especially to illustrate results properly, it is necessary to know the general demographic, socio-cultural and spatial profile of the study area. So, general information about the upazila is provided below:

Table 3: General Information of Upazilas

Parameters	Dinajpur Sadar Upazila	Chirirbandar Upazila
Area	354.73 sq. Km.	312.69 sq. Km.
Households	111779	68415
Population	484597	292500
Literacy Rate	64.3%	52.9%
Average Size of Household	4.19	4.26
Main Occupation	Agriculture	Agriculture
Main Agricultural Products	Rice, Maize, Potato, Tomato, Wheat, Jute, Mustard, etc.	Rice, Maize, Potato, Wheat, Jute, Lentils, and Tomato.
Total Irrigated Area	65600 ha.	62839 ha.
Total Crop Production	150009 metric tons	Approximately 114767 metric tons
Total Crop Demand	90925 metric tons	N/A
Population Density	1366 per sq. km.	935 per sq. km.
Uses of Chemical Fertilizer	25803 metric tons	20020 metric tons
Number of Rice Mills	440	201
Total Cropped Area	70566 acres.	67528 ha.
Main Export Products	Kathari Bhog Rice, Litchi etc.	Rice and Litchi.

Source: BBS, 2011

4.4 Locations of the Study Area

As the rubber dam project is situated between two upazilas of Sadar and Chirirbandar of Dinajpur District, study villages are also located in both upazilas. Parameshwarpur is located in Dinajpur Sadar Upazila, while the other two villages are located in Chirirbandar Upazila. Even, though the dam is on the river Atrai, the Atrai River is connected with the Kakra River near the banks of Dhakail village.

Table 4: Locations of Study Area

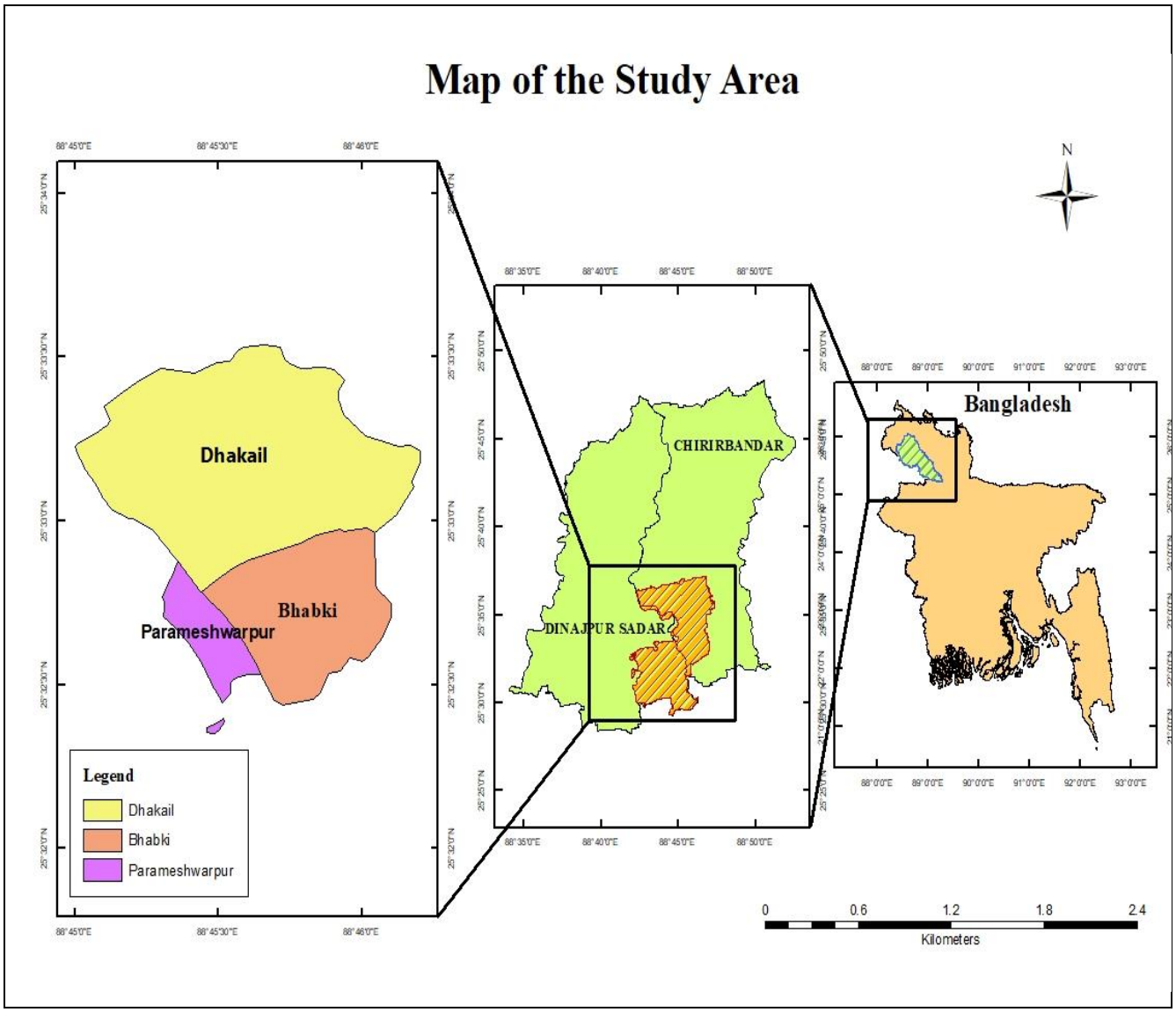
Villages that were investigated	Unions	Upazila	Absolute Location	District
Parameshwarpur	Shankarpur Union	Dinajpur Sadar Upazila	25.539658° N to 25.541498° N 88.758452° E to 88.756993° E	Dinajpur District
Bhabki	Bhiail Union	Chirirbandar Upazila	25.540258° N to 25.545428° N 88.760834° E to 88.761757° E	
Dhakail	Bhiail Union	Chirirbandar Upazila	25.544847° N to 25.551371° N 88.756950° E to 88.756542° E	

Source: Field Survey, 2023

Photo 3: Mohonpur Rubber Dam Project

Source: Google Earth Pro

Map 1: Satellite Map of Mohonpur Rubber Dam



Source: ArcMap 10.8

Map 2: Study Area Map

4.5 Conclusion

This chapter tried to provide a comprehensive overview of the subject field and explain the rationale behind selecting this region for scholarly investigation. It is a prerequisite to have proper knowledge about the study area from various points of view. The researcher should have a proper understanding of the demographic, social, spatial, and economic aspects of the study area, thus the chapter provided a little glimpse regarding the relevant information. A map was also produced to demonstrate the specific location of the villages that were extensively studied. However, the information presented in the chapter is hoped to help later in understanding and explaining the study findings.

Chapter 05: Results and Discussion

Rubber Dam technology became a very common and necessary project around the world to support agriculture from surface water sources. Even, both public and private stakeholders want to shift irrigation sources from groundwater to surface water sources due to the high depletion rate of the groundwater table. Extreme withdrawals of groundwater lead to the depletion of groundwater levels, creating an enormous crisis for both agriculture and other uses. However, Bangladesh being a riverine country has huge potential to use surface water sources for supporting agriculture. Thus, the Government of Bangladesh (GoB) introduced several rubber dams around the country in order to provide irrigation facilities. Rubber dams provide multiple benefits ranging from irrigation facilities to fish availability, which later impacts the socioeconomic conditions of local stakeholders. The present study demonstrated the agricultural and socioeconomic impacts of the Mohonpur Rubber Dam project on the local people under the Dinajpur districts of Bangladesh.

5.1 Profile of the Respondents

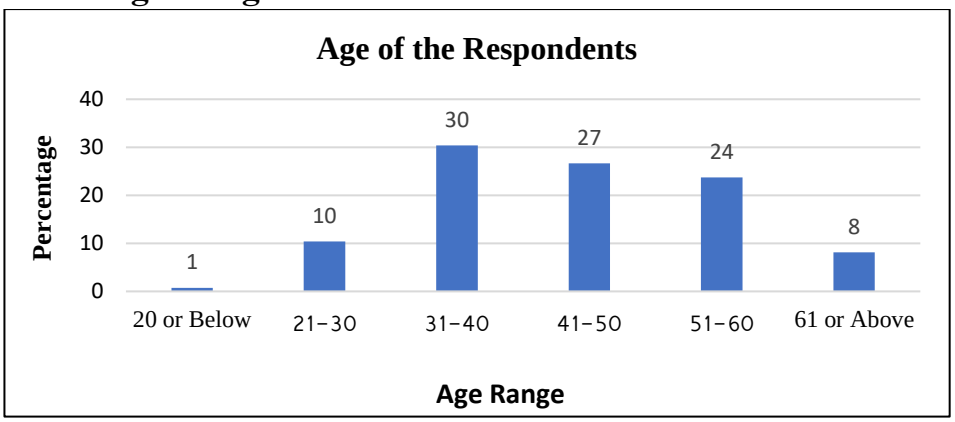
The details of the surveyed respondent's profile are presented below:

Table 5: Profile Details of the Respondents

Factors	Categories	Percentage
Gender	Female	17 %
	Male	83 %
Religion	Islam	59.3 %
	Hindu	40.7 %

Source: Field Survey, 2023

5.2 Respondents' Age Range



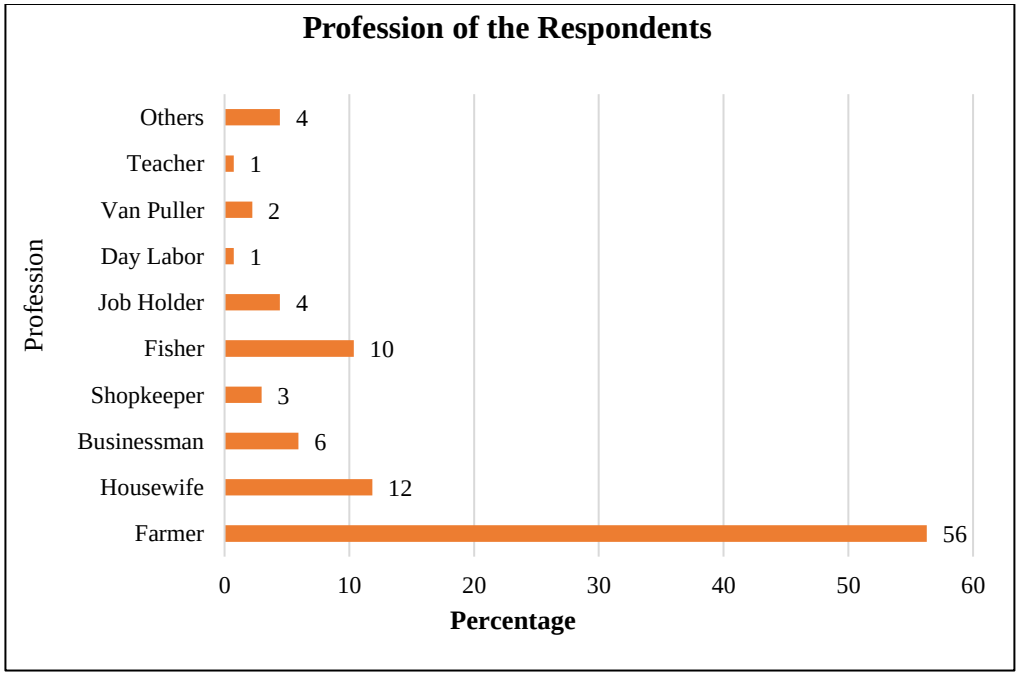
Source: Field Survey, 2023

Figure 2: Age of the Respondents

As the questionnaire survey was conducted on a household basis, the targeted respondents were mostly family heads. Generally, in the context of our country, family heads are the earning members of the family. Results show the dominant age groups are (31-40) and (41-50) years old. The 31-40 years category accounts for about 31 percent of the total respondents while the 41-50 years category demonstrates 27 percent, which is the second largest category according to the respondents.

5.3 Profession of the Respondents

The study area is extensively agriculture dependent. Rice is the main production food, while potatoes, maize, and other vegetables are also cultivated on a great scale. The collected data represents that farmers are the highest category among the respondents. In three villages that were surveyed results that about 56.3 percent are farmers, who are directly engaged with the rubber dam projects in the form of stakeholders. Fisher community accounts for 10 percent, and they mostly belong to Dhakail village, a Hindu-dominant village. The study shows that fisher communities are at decreasing trends migrating their profession to farmers as farming is comparatively profitable in the study. Because the study area is highly suitable for High Yielding Variety (HYV) rice production. The women population in the study were mostly housewives assisting their husbands in their farming activities. Thus, around 11.9 percent of housewives gave their statement.

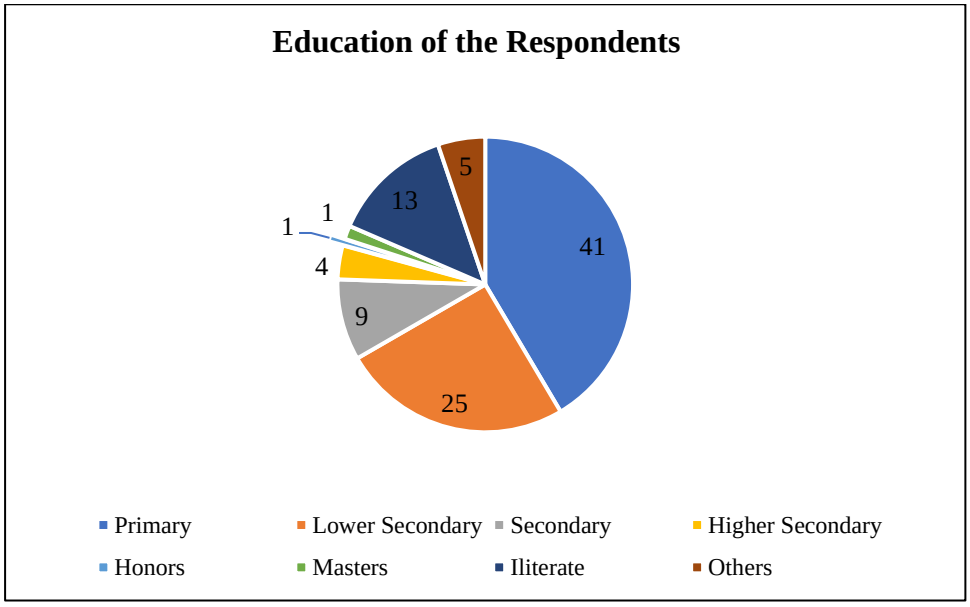


Source: Field Survey, 2023

Figure 3: Respondent's Profession

5.4 Respondents' Education

Education is among the basic needs of humans and is considered to be one of the most fundamental instruments for development. Education plays a vital role in the economic freedom of people. Moreover, education helps to determine the profession of people on a greater scale. After finishing one's formal education at an institution, a person always tries to find a suitable job. But in the case of the study, education seems to have very little impact on the career development of locals.



Source: Field Work, 2023

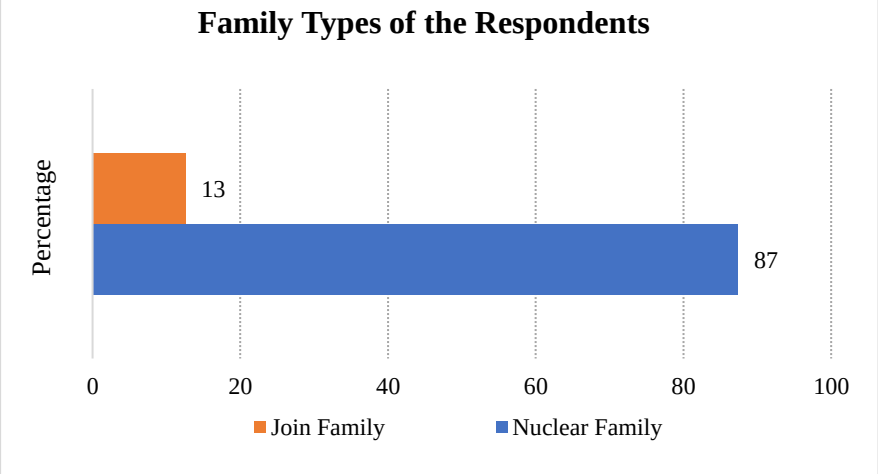
Figure 4: Respondents' Education Level

According to the results, 41 percent of respondents only have primary education employing mostly in the agricultural sector, which is the dominant percentage among the respondents. 25 percent of respondents only have lower secondary education while illiterate respondents accounted for 13 percent. The higher education percentage is very low among the respondents. According to the respondents, due to their low economic status, most of the children have to give up their education and contribute to family income. Due to its heavily agriculture-focused economy, Dinajpur residents are able to easily secure employment within the agricultural industry. Thus, they prefer to remain in agriculture for their livelihood.

5.5 Family Information of the Respondents

Having an understanding of the family structure of the respondent is important in gaining knowledge about their livelihoods. Family structure reflects the population growth as well as

the socioeconomic conditions of the respondents. According to the observed data, the nuclear family consists of a greater percentage of the respondents, which is about 87.4 percent. Joint family accounted for only 13 percent of the entire population. Among three separate villages, Dhakail, a Hindu-dominant village, represented a greater percentage of joint families. According to a respondent, joint families are high in Dhakail due to some reasons though it is now in a decreasing trend. The study suggested the percentage of househusbands is high in the village. It appeared that some women who were married in other regions have returned permanently with their husbands to live on their father's property. According to them, Dhakail is highly fertile and capable of producing high amount of rice grains than other areas. Thus, husbands found it easier to get a job. Moreover, agriculture is profitable in the study area, so they have chosen to return.



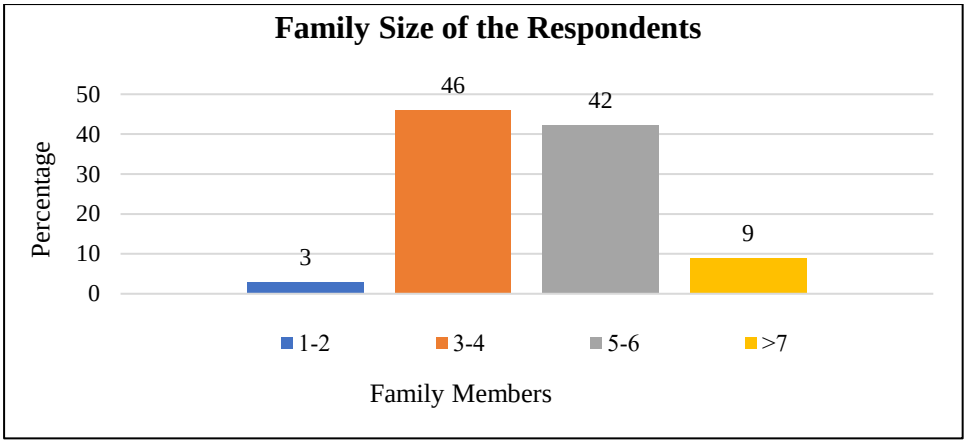
Source: Field Survey, 2023

Figure 5: Respondent's Family Type

5.6 Family Size of the Respondents

According to the study, families consisting of (3-4) members are high in percentage among the respondents, which is about 50 percent among the respondents. The second largest category consisting of (5-6) members, accounts for 42 percent. Members consisting of more than 7 people also accounted for about 9 percent, marking Joint families.

The study also suggests that the percentage of the nuclear family is constantly growing due to the growth of individualism. The concept of individualism is very popular in the Western world, but currently, it migrated to the Eastern world breaking joint families into nuclear families. The constant growth of the nuclear family leads to the distribution of land property, which is the main barrier to extensive commercial agriculture.



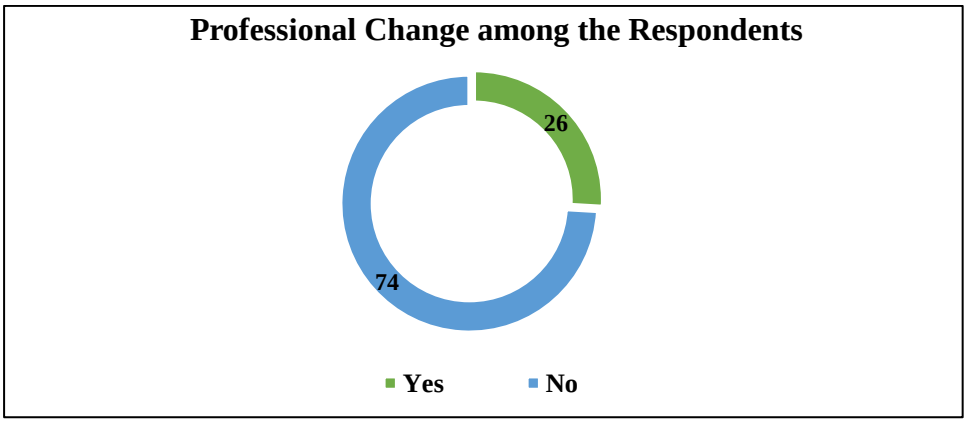
Source: Field Work, 2023

Figure 6: Family Size of the Respondents

Even, it is believed that more nuclear family means more land property distribution, which will create boundaries in a big land resulting in the reduction of arable land to boundaries. These finally affect the total crop production of a country. According to the Household and Demographic Characteristics Survey 2022, the average household size in Bangladesh is 4.26 people. The study result suggests the average household size is pretty high from the national average in the study area.

5.7 Professional Change Among the Respondents

According to the field survey, 74 percent of respondents did not change their profession in the last 15 years, while 26 percent of respondents changed their profession. The majority of the respondents did not change their profession as they were previously engaged in agriculture. As agriculture becomes viable after the installation of rubber dams, the professional dynamic did not appear among the respondents.



Source: Field Survey, 2023

Figure 7: Professional Change among the Respondents

Even, study results showed that a higher percentage of people migrate to be a farmer from various professions, as farming is considered to be a profitable profession according to several respondents. Recorded data reflected that about 20 percent of shopkeepers have left their profession to become farmers, while van pullers also change their profession into farmers. In the research region, there are more people becoming farmers due to professional changes leading to the growth of farmers.

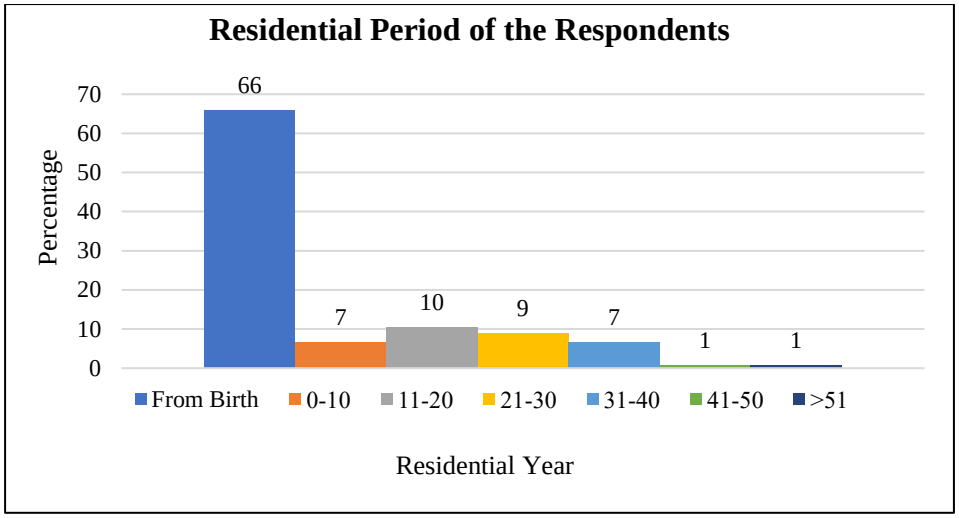
Table 6: Professional Change before and after rubber dam installation

Before Dam	After Dam	Percentage
Security Guard	Farmer	2.86%
Fisher	Farmer	5.71%
Farmer	Van Puller	8.57%
Shopkeeper	Farmer	20%
Van Puller	Farmer	14.29%
Raw material Business	Shopkeeper	2.86%
Garments Worker	Farmer	5.71%
Expatriate	Farmer	5.71%
Job Holder	Farmer	8.57%
Farmer	Business	2.86%
Job Holder	Shopkeeper	2.86%
Farmer	Farmer + Shopkeeper	2.86%
Farmer	Shopkeeper	5.71%
Day Labor	Farmer	8.57%
Tailor	Farmer	2.86%

Source: Field Work, 2023

5.8 Residential Period

According to the information collected from the field survey, 66 percent of respondents were living in the study from their birth. It indicated that they were not migrants, they have owned lands and houses from their ancestors. Due to cultural assimilation, it was quite tough to identify who is permanent and who has migrated earlier in the region. The second highest percentage is 10 percent, this is the category of those who have migrated and have been living in the region for 11 to 20 years. Several women were also counted here as they migrated due to marriage. The emigration and immigration both rates were very low in the region, people prefer to stay in their own locality.

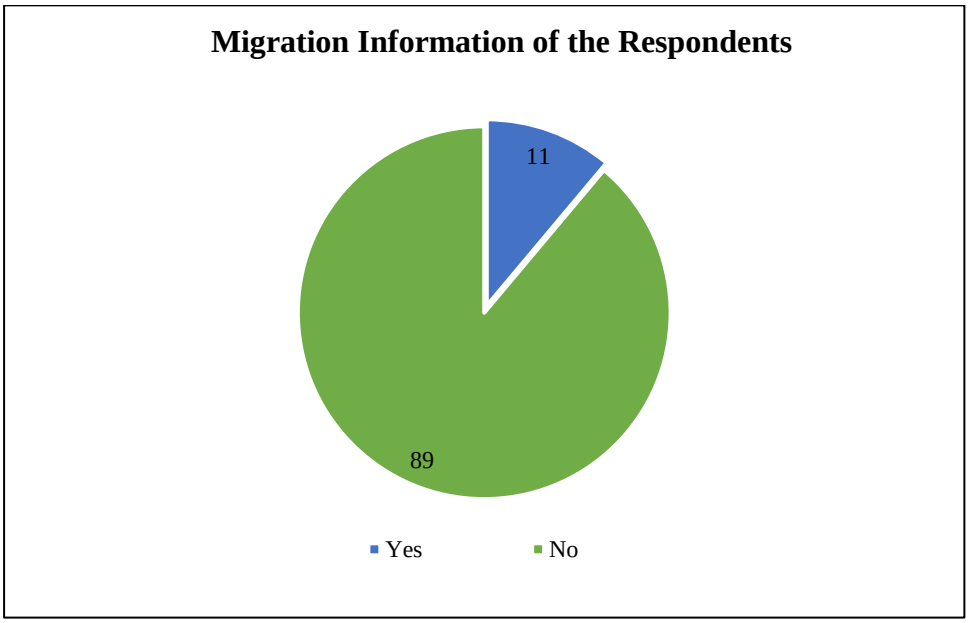


Source: Field Survey, 2023

Figure 8: Residential Period of the Respondents

In the case of the study area, agricultural activities are dominant and to some degree, agriculture is considered to have viability. Thus, people need not migrate in search of jobs. The study suggested, most of the respondents have been staying here for a long period of time.

5.9 Migration Information



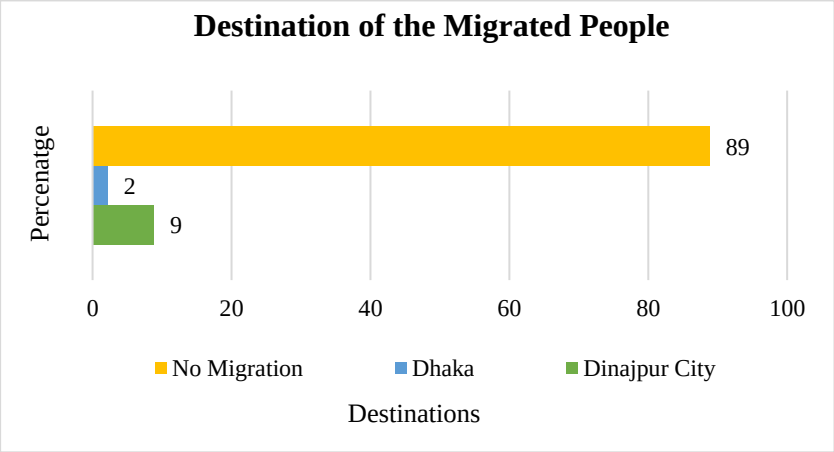
Source: Field Survey, 2023

Figure 9: Migration Information of the Respondents

Migration rate is comparatively very little as the study found. Only 11 percent of the respondents talked in favor of migration. According to some respondents, some people who were migrant workers in Dinajpur or Dhaka city before, are returning to villages employing

themselves in agriculture or factories (rice mills). Local laborers found jobs in rice mills, which were established in a greater amount in the region due to the availability of different rice as a raw material. About 89 percent of the respondents denied the possibility of migration saying they are not interested to migrate. Even according to some of the respondents, migration is kind of disrespectful to them. They mentioned that, leaving their ancestor's property was very incongruous and fabled.

5.10 Destination of the Migrated People



Source: Field Survey, 2023

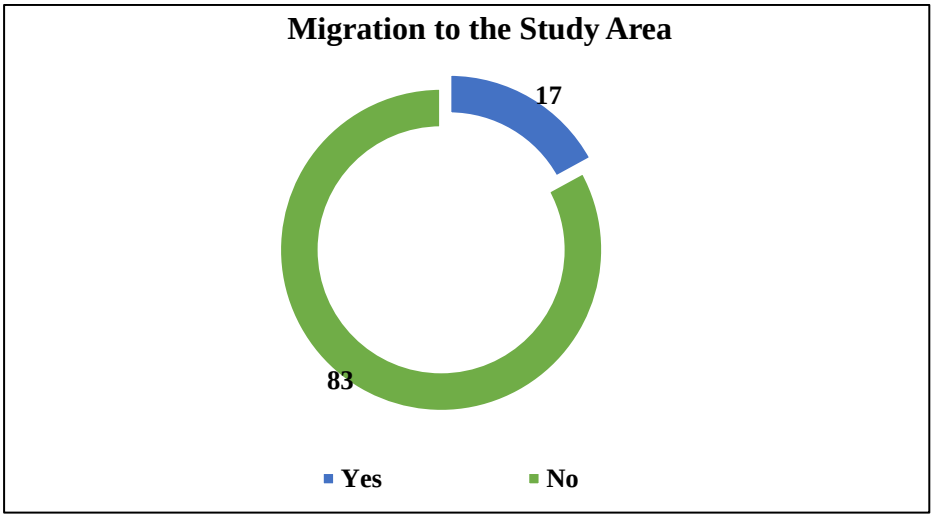
Figure 10: Destination of the Migrated People

The respondents who answered in favor of migration replied primary migration destination is Dinajpur City for them. Dinajpur City lies within 20 kilometers of rubber dam area, thus making it a primary destination for locals. Around 9 percent of the migrant people primarily seek employment in Dinajpur City. The majority of them shift their profession to become auto-rickshaw/van pullers, while some of them were employed in different factories. Only 2 percent of the respondents choose to migrate to Dhaka City. During interviewing, an interviewee who was currently migrated to the Dhaka Hazaribagh area mentioned that he left the village 6 years ago. Currently, he was working in a leather processing factory in the Hazaribagh area earning him a pretty good salary which was almost impossible in his village Parameshwarpur. Though, the respondent had not much land except his homestead. Moreover, it appeared respondents, who do not have much land property tend to migrate to nearby cities primarily in Dinajpur than in Dhaka. The patterns expressed the trace of ‘the Relay Migration’.

5.11 Migration to the Study Area

The percentage of migration was also very low in the study area. About 83 percent of the

respondents replied they did not observe immigration, while 17 percent of the respondents observed immigration. According to the findings of the survey, Dhakail village experienced a high migration rate which mostly occurred due to marriages. Several respondents answered about the return of married women to their father's house with husbands and children permanently. Even, the village was widely known for its greater number of househusbands. Among some other exceptions, the result indicated immigration rate was extremely high in Dhakail village in the form of househusbands.

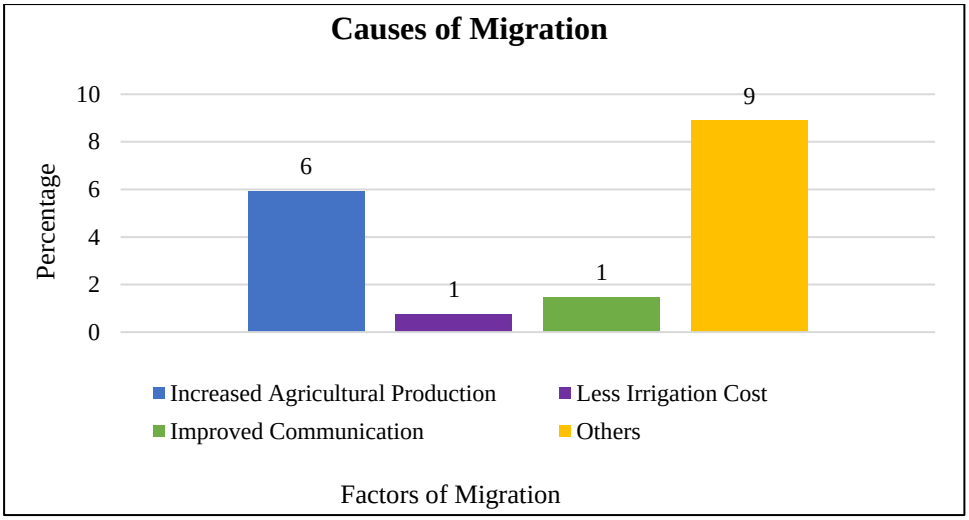


Source: Field Survey, 2023

Figure 11: Migration to the Study Area

5.12 Causes of Migration

Respondents who answered in favor of migration to the study area identified several reasons for internal migration. The study suggested that 6 percent of the respondents believed increased agricultural production attracts migrants to the study area. Due to the installation of the Mohonpur Rubber Dam, agricultural production has increased, reducing irrigation costs. It makes agriculture profitable thus attracting migrants from nearby areas. About one percent of the respondents answered migration generally occurred due to improved communication. It should be mentioned that several roads and even highways connecting Dinajpur to Rangpur and Rajshahi were amplified widely. While 9 percent of the respondents recognized some other causes of immigration which included fish availability, tourist arrival, shopkeeping business etc. However, migration and immigration both are too low in comparison with different area of the country. The people of the study area are industrious and farming is their main profession earning them livelihoods.

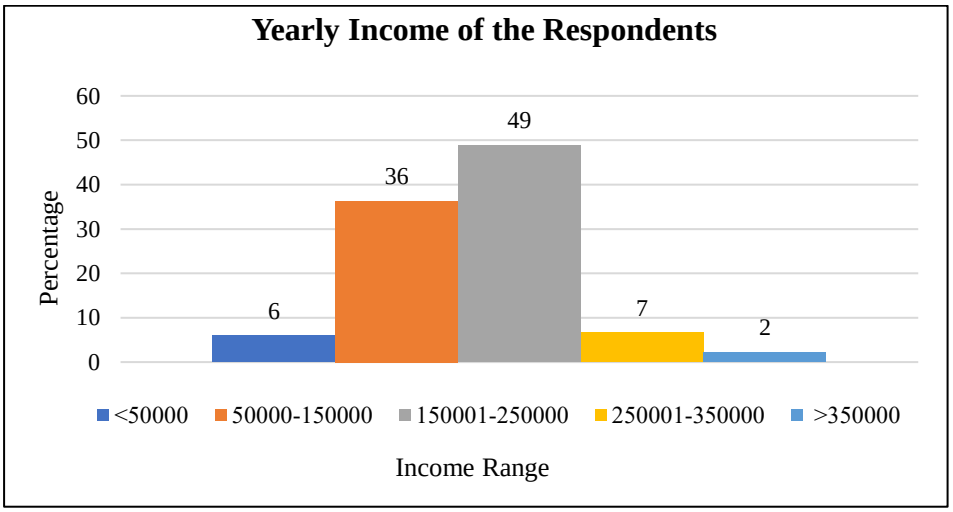


Source: Field Survey, 2023

Figure 12: Causes of Immigration

5.13 Yearly Income of the Respondents

Understanding society and the economy requires access to socioeconomic survey data. Individual and family income and expenditures as well as job patterns and general economic health were shown by these numbers. The economic data collected in these surveys wass essential for making informed policy decisions, implementing effective interventions, and measuring societal development. Surveys of this kind aimed to measure the economic and social status of a certain population. Economic information provided crucial context for social outcomes, making it essential for this function.



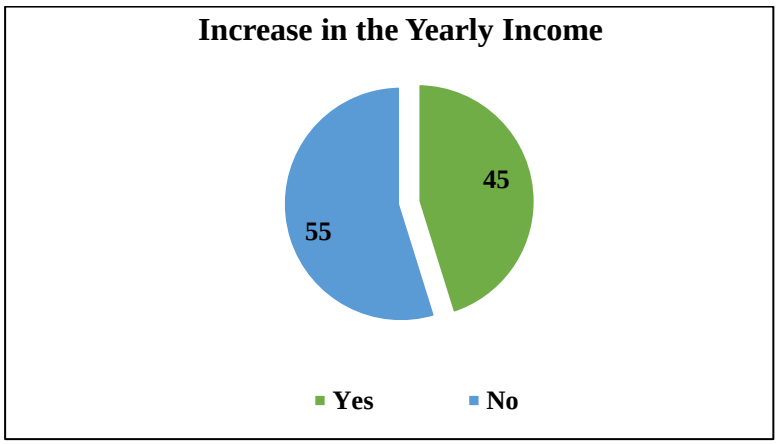
Source: Field Survey, 2023

Figure 13: Yearly Income of the Respondents

It's impossible to get a handle on poverty, inequality, and social mobility without first knowing how money is distributed and where people may find jobs. The quality of life may be better understood in light of economic data. Income groups were higher with a percentage of 49 percent in (150000-250000). As most of the respondents were farmers, they tend to have similar or proximate income status. According to the HIES 2022 findings, the mean monthly family income is at Tk. 32,422 on a national scale, while it amounts to Tk. 26,163 in rural regions. So, it is clear from the collected information that 98 percent of the respondents are living below the average rural income range. And in this age of economic recession and inflation, most of the respondents in the study area can be identified as poor.

5.14 Increase in Yearly Income

A substantial majority, including around 55 percent of the participants, said that they did not see any rise in their income. The group asserted that its revenue has not seen any changes in comparison to the preceding time. While 45 percent of respondents observed a slight increase in their income after the implementation of the Mohonpur Rubber Dam. The people who have seen a slight increment in their yearly income have perceived some factors affecting their livelihoods.



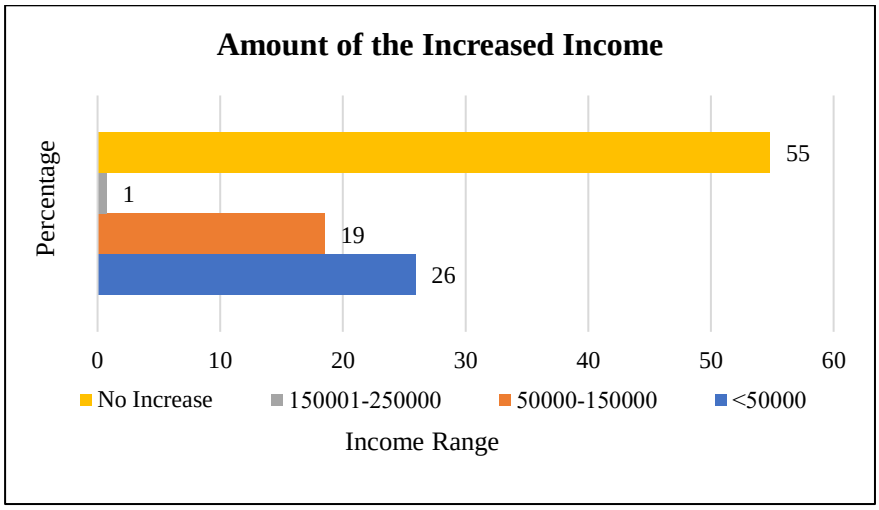
Source: Field Survey, 2023

Figure 14: Increase in yearly Income

Rubber dam facilitates irrigation, which assisted in the enhancement of yield production leading to a sharp increase in their family income. Moreover, fish availability, improved communication, tourist arrival, and boat roaming have jointly affected the livelihoods raising income. Yield production has seen a sharp growth after the installation of the rubber dam (KII-1)

5.15 Amount of Increased Income

This finding suggested that about 26 percent of the participants hold the belief that their annual income has seen a rise of less than Tk. 50,000 as a result of the implementation of the Mohonpur rubber dam project. The participants in this study area noticed a marginal increment in their yearly earnings. between this particular group, around 18 percent of the participants indicated a perceived rise in their annual income falling between the range of Tk. 50,000 to 150,000. This finding indicated that a subset of participants has saw a modest rise in their yearly earnings as a result of the initiative. Within this limited spectrum, it is seen that around 1 percent of the participants report a rise in their annual income ranging from Tk. 150,001 to 250,000. This finding also suggested that a minority of participants see a substantial increase in their income as a direct result of the study.



Source: Field Survey, 2023

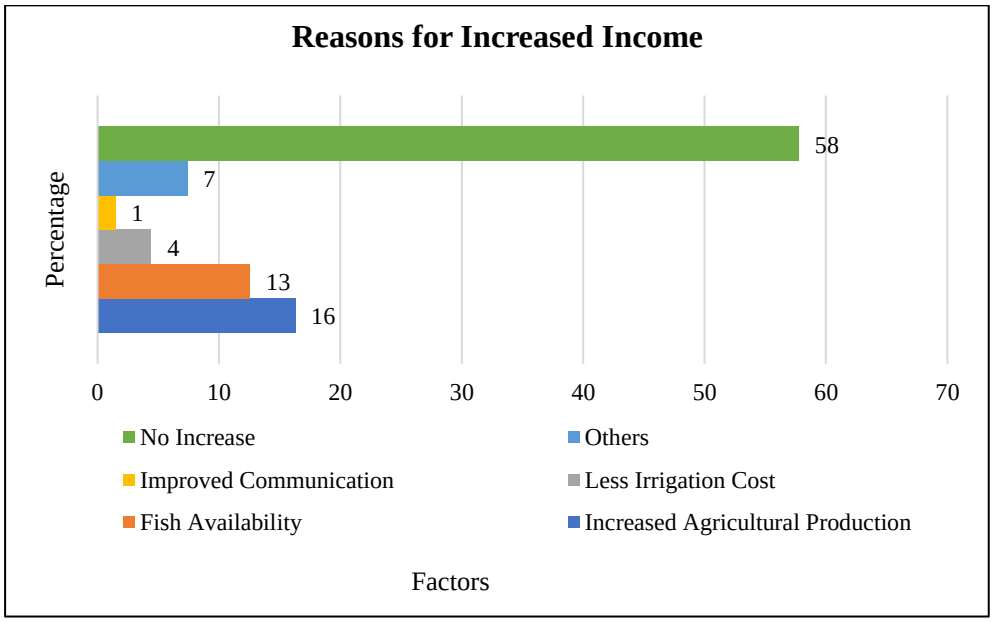
Figure 15: Amount of the Increased Income

Moreover, locals were able to grow litchi and mango along the river bank increasing fruit production. Because of the water retention during the dry season, fruit trees were able to produce more fruits than before. Even, several vegetable fields were also found along the bank of the river. Moreover, fish caught from the rubber dam area has very high demand owing to its special taste and flavor. The respondents mentioned the sharp increase in annual income.

5.16 Reasons for Increased Income

This finding suggested that around 16 percent of the participants observed the growth in their

income due to an increase in agricultural output. The data indicated that participants have seen greater agricultural production or productivity, resulting in a subsequent rise in their income. Approximately 13 percent of the participants credited their augmented income to the accessibility of fish. This observation suggested that individuals residing in regions with opportunities for fish-related pursuits, such as fishing or aquaculture, have seen an increase in their financial earnings as a result of the ample availability of fish resources. Around 4 percent of participants said that their income growth is associated with decreased expenses related to irrigation. This implies that the reduction in expenditures, specifically related to irrigation practices such as water use and equipment, has had a favorable impact on their revenue.



Source: Field Survey, 2023

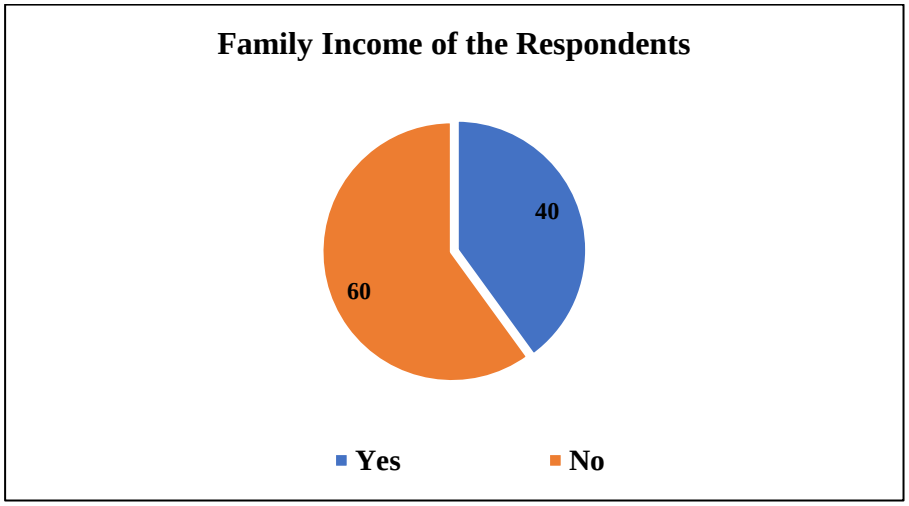
Figure 16: Reasons for Increased Income

Approximately one percent of the participants credited their rise in salary to enhanced communication skills. This observation suggested that the presence of improved communication infrastructure, such as expanded connectivity, played a role in enabling business transactions, sales, and market access, hence leading to a subsequent rise in revenue. Approximately 7 percent of the participants reported other factors contributing to their rise in income, namely tourists, shop business, Rice processing, vegetables, and fruit trees growing along the banks of the river etc.

5.17 Family Income of the Respondents

According to the field survey data, about 40 percent of the respondents that they own a family

income. The data suggested that a considerable proportion of the respondents have verified that their households get a type of financial resources, which originated from diverse channels such as agricultural work, jobs, or other revenues. About 60 percent of respondents indicated that they do not contribute financially to the household. This suggested that the vast majority of those surveyed had families who were financially struggling. In conclusion, the data demonstrated the distribution of answers depending on whether or not respondents came from households with financial resources. The percentages represented how many people in each group responded. This data might help in better understanding the economic dynamics, social inequities, and possible linkages between these and other factors of interest to your study or analysis.

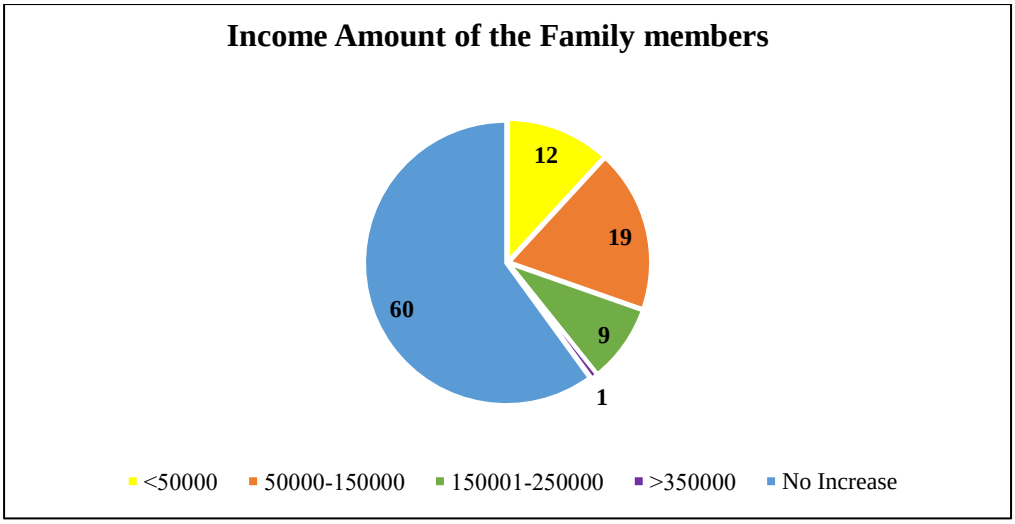


Source: Field Survey, 2023

Figure 17: Family Income of the Respondents

5.18 Income Amount of Family Member

From the field survey, it has been found that about 12 percent of the participants stated that the salaries of their family members are below Tk. 50,000 yearly. Approximately 18 percent of participants indicated that the salaries of their family members are situated within the range of Tk 50,000 to Tk 150,000. This category generally encompassed salaries that are often associated with the lower to lower-middle class. Around 9 percent of participants indicated that the salaries of their family members are situated within the range of Tk. 150,001 to Tk. 250,000. This category often encompassed those with higher income levels, commonly classified as belonging to the middle class in the context of rural Bangladesh. Approximately 1 percent of the participants said that the salaries of their family members were above the threshold of Tk. 350,000 referring to the higher-middle class families.

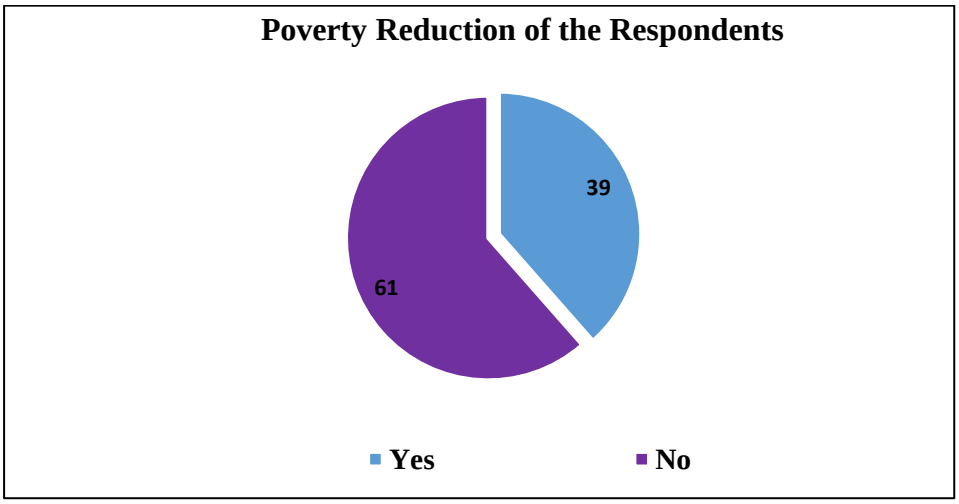


Source: Field Survey, 2023

Figure 18: Income Amount of the Family members

5.19 Poverty Reduction of the Respondents

From the field survey data, it has found that around 61 of the respondents did not observe any reduction of poverty after the installation of Mohonpur rubber dam project.



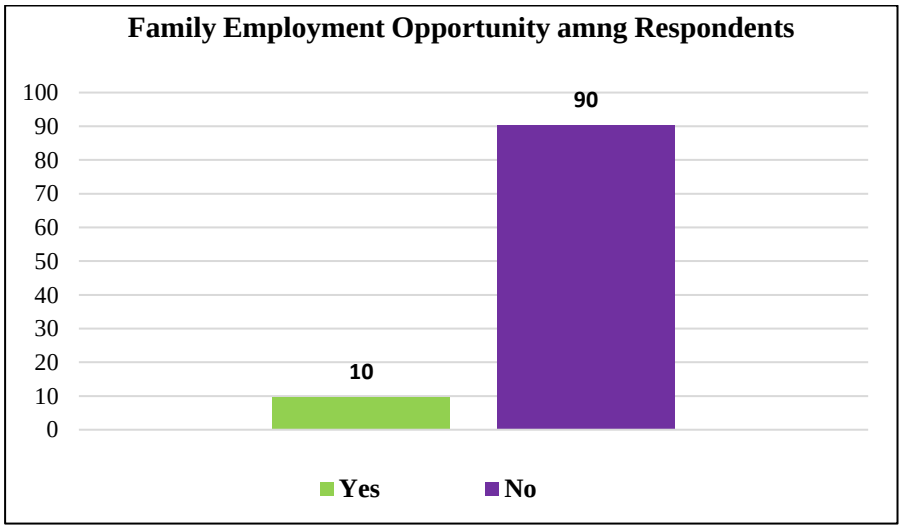
Source: Field Survey, 2023

Figure 19: Poverty Reduction in Percentage

The participants in this study expressed that their economic circumstances have not seen sufficient improvement to the point where they could discern a reduction in the amount of poverty they were previously encountering. About 39 percent of the respondents, observed that poverty rate decreased. According to these respondents, their financial situation had improved to the point that they no longer feel as if they are living in poverty. The information provided valuable insights into the perceived alterations in poverty rates among the studied population.

The examination of the rubber dam regarding economic dynamics, social development, and inequities within the framework of poverty reduction has potential value in comprehending these phenomena. Furthermore, it was important to assess the extent to which these views coincide with the economic situations reported by the respondents. Furthermore, the data presented an accurate depiction of the economic ramifications associated with the implementation of a rubber dam. In rural Bangladesh, the number of poverty-stricken people is very high. Thus, govt. always attempts to formulate the kind of projects that necessarily assist to reduce the percentage of poverty.

5.20 Family Employment Opportunity Among the Respondents



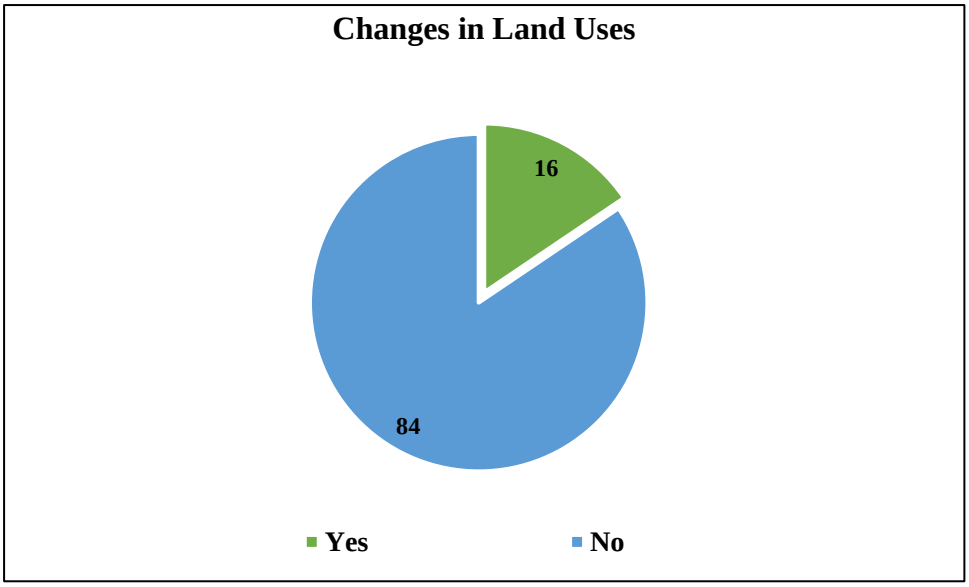
Source: Field Survey, 2023

Figure 20: Family Employment Opportunity among Respondents

The majority of the respondents, namely 90 percent of the respondents did not observe any kind of work prospects that could employ the family members. The responders expressed that the development of the Mohonpur Rubber Dam has resulted in a lack of career prospects and work opportunities for family members. According to the research, it has been suggested that the dam did not generate any job prospects within the region under investigation. About 10 percent of the respondents observed the presence of work possibilities within their family. The participants in the survey asserted that family members had access to work possibilities or employment opportunities, which had the potential to enhance their family's total income and financial stability.

5.21 Changes in Land Uses

Land use change is a substantial process that is propelled by a multitude of reasons, including economic, environmental, and social effects. Rubber dams, often used in the realm of water management, have the capacity to influence land utilization patterns within their immediate area. As the structure was built to facilitate the irrigation process, thus it directly affects agriculture. And land use changes are a vital subject of geography.



Source: Field Survey, 2023

Figure 21: Change in Land Uses

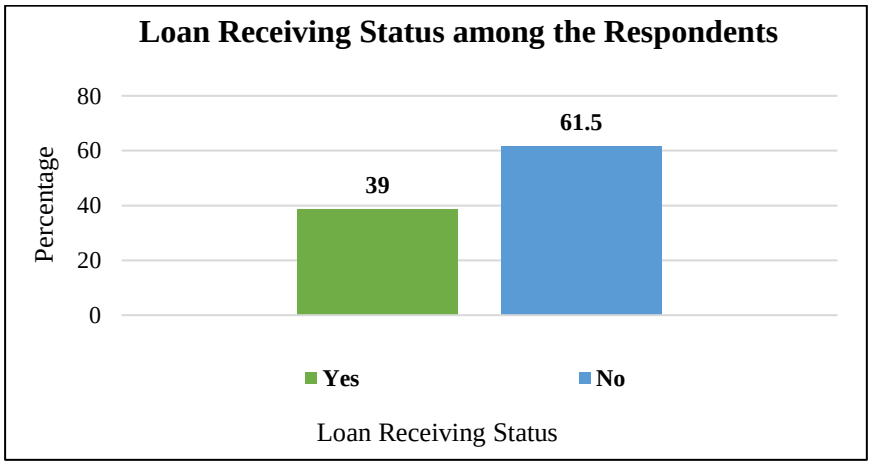
Source: Field Survey, 2023

Photo 4: Litchi Garden which was barren land before the installation of rubber dam

So, we asked the respondents if they notice any changes in land use patterns after the installation of rubber dam in Mohonpur area. Almost 84 percent of the respondents did not notice any change in land use patterns while only 16 percent of the respondents observed a slight change in the land use patterns of the study area. The people who observed changes in land use patterns mentioned some of the features responsible for the change in land use. Several shops were established as the dam area has become a tourist destination, and different fruit trees are found along the bank of the river.

5.22 Loan Information of the Respondents

In the field of socioeconomic research and analysis, it is vital to comprehend the loan and deposit data of respondents in order to evaluate their financial well-being, behavioral patterns, and economic engagements. This data offers significant insights into the manner in which respondents engage with financial institutions, handle their money, and contribute to the wider financial ecosystems. Loan and deposit data from respondents help socioeconomic researchers understand financial behavior, economic activity, and societal trends. The data revealed that within the research or sample, 39 percent of the respondents have been recipients of a loan, whilst the remaining 61 percent have not obtained a loan. This data offered valuable insights into the frequency of loan use among the participants. The data indicating that 39 percent of participants had obtained a loan suggested the prevalence of loans is notable among the investigated sample. The observed distribution might potentially reflect several reasons, including the accessibility of credit, financial requirements, prevailing economic conditions, and individual financial tendencies.

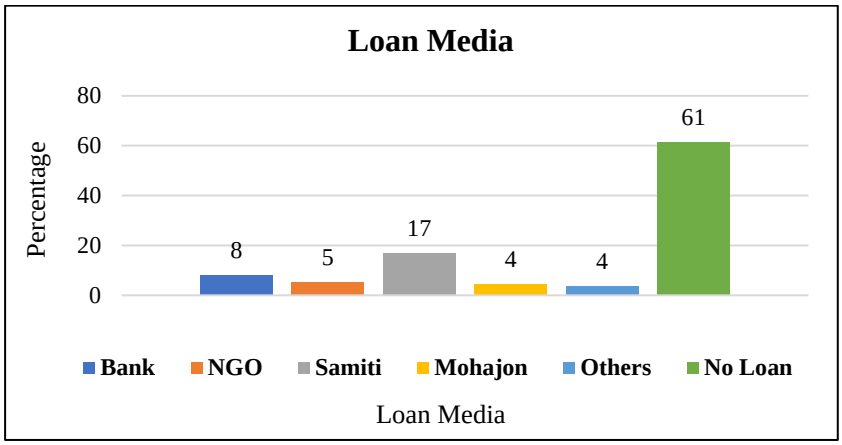


Source: Field Survey, 2023

Figure 22: Loan Receiving Status

5.23 Information regarding Loan Media

The data provided various channels or mediums via which participants acquired loans. The sources are classified into many categories, including Banks, Non-Governmental Organizations (NGOs), Samiti (cooperative society or organization), Mohajon (local money lender), Others (other sources), and No Loan. A total of 8 percent of the participants in the study area reported of acquiring their loans via conventional banking institutions. From a NGO, a total of five percent of the participants acquired loans, entities that often provided microfinance and other financial services to marginalized communities.



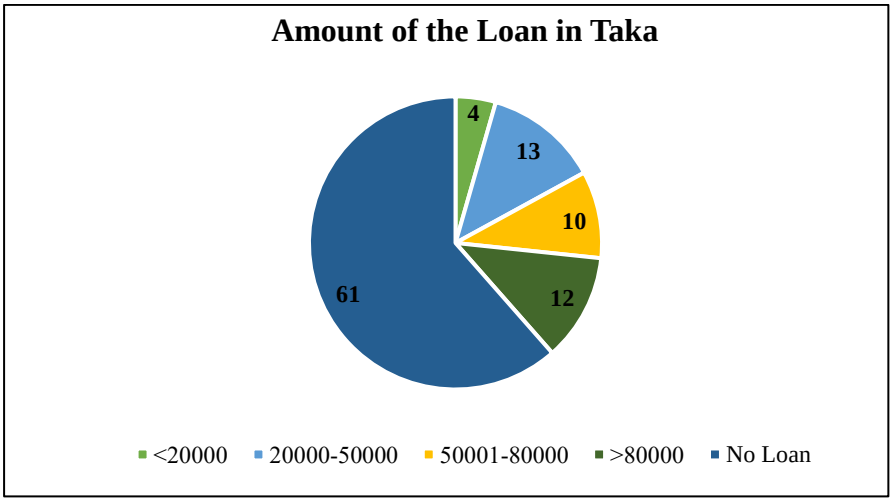
Source: Field Survey, 2023

Figure 23: Loan Media

From Samiti, a total of 17 percent of the participants received loans from a cooperative or group, perhaps indicating the use of a community-oriented lending mechanism. From Mohajon a total of 4 percent of the participants received loans from local money lenders or private persons. Others A total of 4 percent of the participants acquired loans from other sources such govt. agencies, projects etc. They were generally local money lenders providing loans with high-interest rates along with captivating mortgages. A majority of the respondents, namely 61 percent mentioned that they did not acquire any loans. This information has significant value in comprehending the wide array of sources from which people are procuring loans. This analysis emphasized the significance of official financial institutions, such as banks, as well as alternative financial providers, such as NGOs. Additionally, it acknowledged the importance of community-based financing via samiti and the involvement of informal sources, such as local money lenders.

5.24 Amount of the Loan

The number offered gives valuable insights into the distribution of loan amounts among respondents who have availed themselves of loans. About 4 percent of the participants had acquired debts amounting to fewer than Tk. 20,000. A greater proportion 13 percent of participants had obtained loans within the range of Tk. 20,000 to 50,000. An additional cohort, comprising 10 percent of the total, received loan ranging from Tk. 50,001 to 80,000. A significant proportion (12 percent) of the participants had acquired debts over the threshold of Tk. 80,000. A significant proportion of the participants (61 percent) mentioned that they did not avail themselves of any financial facilities.



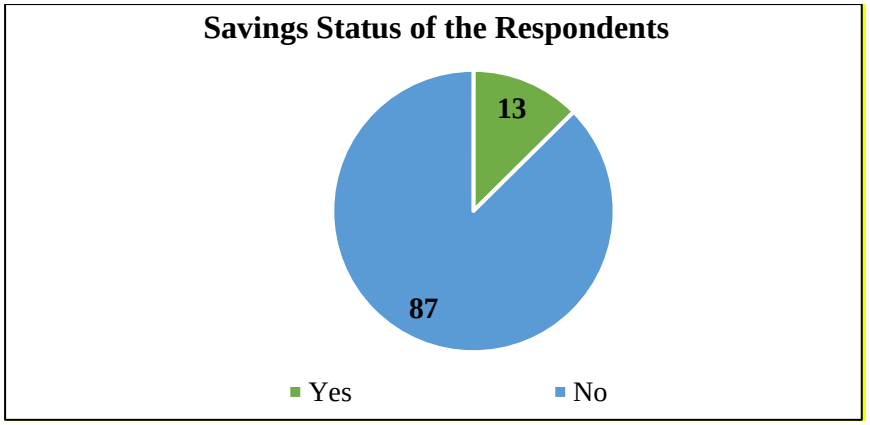
Source: Field Survey, 2023

Figure 24: Loan Amount

The provided data offered significant insights into the distribution of loan amounts, hence revealing the prevalence of borrowing within certain ranges. This aided academics, financial institutions, and regulators in comprehending the borrowing patterns of people and customizing financial goods and services to accommodate a wide range of borrowing requirements.

5.25 Saving Information of the Respondents

According the findings of the survey, approximately 13 percent of the participants provided an affirmative response when inquired about the presence of savings. Taken otherwise, a comparatively lower proportion of the whole sample mentioned that they own savings.



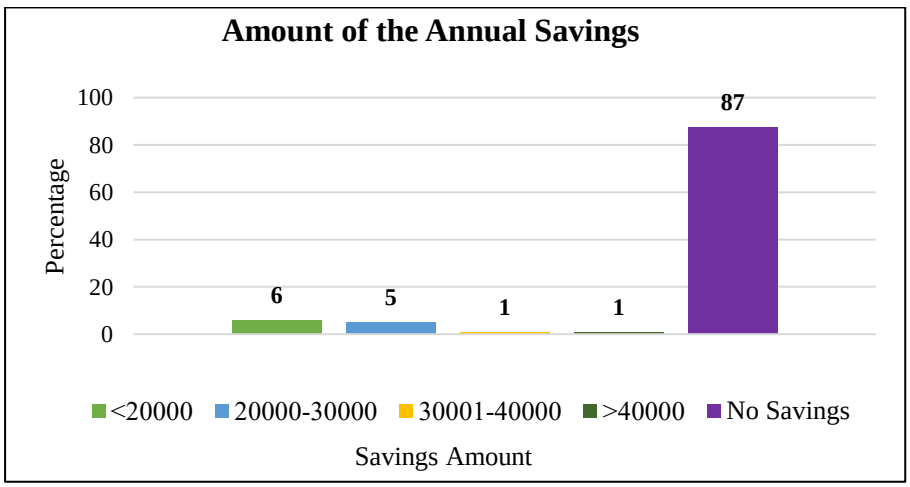
Source: Field Survey, 2023

Figure 25: Savings Status of the Respondents

The majority of respondents (87 percent) indicated a negative response when questioned about the presence of savings. This finding indicated that a significant proportion of the participants did not have any savings. The data suggested that a considerable proportion of the participants are not engaging in savings, potentially impacting their financial stability and long-term strategizing.

5.26 Amount of the Annual Savings

According to the findings of the survey, about 6 percent of the respondents mentioned that, they only had savings amounting to less than Tk. 20000. Around five percent of the respondents had savings with a range between Tk. 20000 to 30000. Another two percent fell within the range of Tk. 30001 to 40000 and more than 40001.

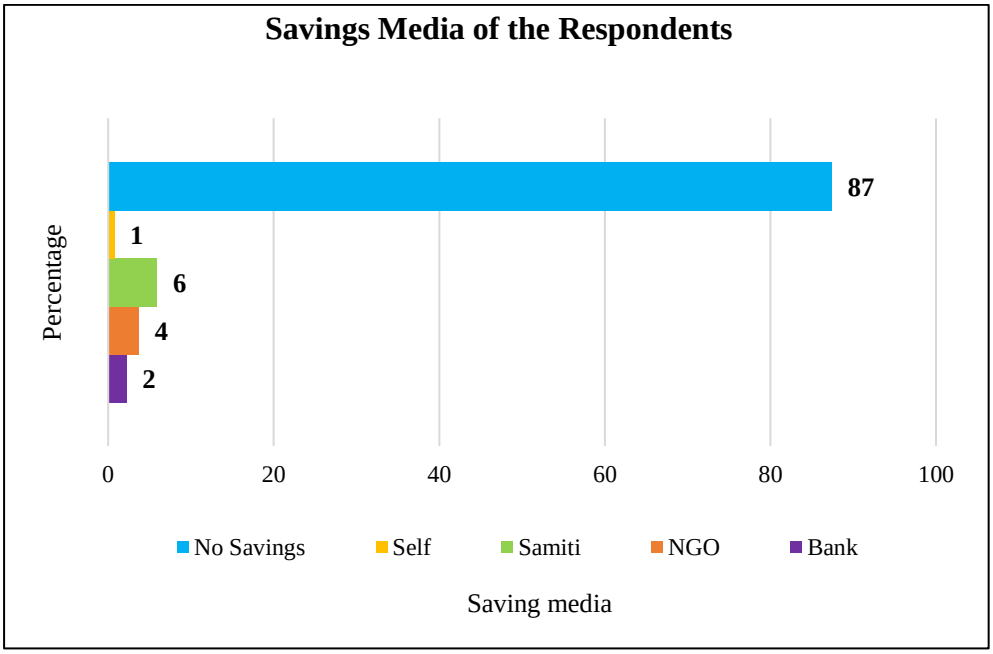


Source: Field Survey, 2023

Figure 26: Amount of the Annual Savings

The largest proportion of participants, comprising 87 percent of the sample, mentioned that they did not own any yearly savings. To summarize, the data presented offers valuable insights into the distribution of yearly savings amounts across the respondents. The findings indicated that a significant proportion of participants have not accumulated any savings, whereas a minority of respondents exhibited varying levels of savings. This information had potential use in comprehending the financial management and future planning strategies employed by people, while also facilitating the identification of possible patterns or disparities depending on income levels.

5.27 Saving Media



Source: Field Survey, 2023

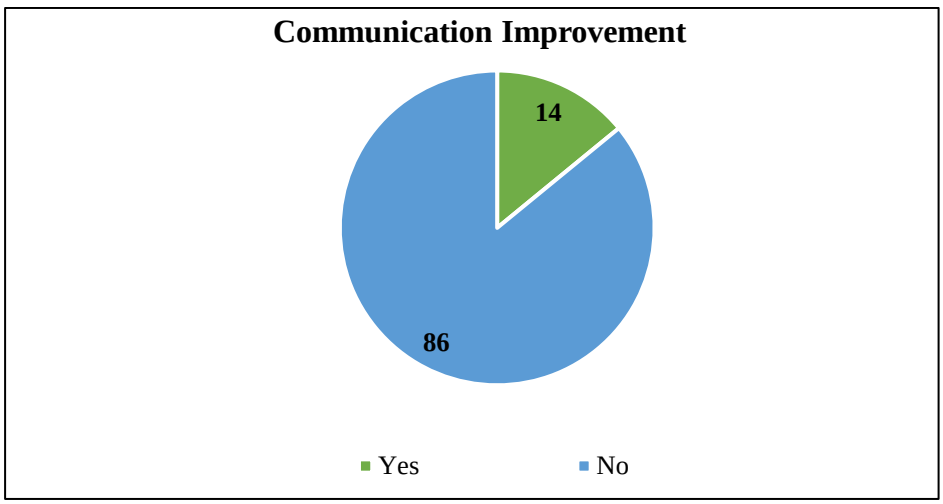
Figure 27: Savings Media

This finding suggested that a minority of the participants, namely two percent had a preference for depositing their funds in a financial institution such as banks. One possible approach to accomplish this objective was to allocate money into a conventional savings account with a financial institution. The figure corresponded to 4 percent of the participants who expressed a preference for saving funds through NGOs. NGOs have the potential to provide people with savings programs and financial services. Within a particular category, a notable 6 percent of the respondents expressed a preference for using a local samiti as their chosen medium for savings. The term "samiti" encompasses a collective, association, or board whereby people collaborate to consolidate their resources for the goals of savings and lending. In a similar vein,

it was found that one percent of participants expressed a preference for independently managing their funds, suggesting a potential inclination towards self-reliance in financial matters. The aforementioned group comprises the largest proportion of participants, accounting for 87 percent, who indicated a lack of savings. In conclusion, the aforementioned data offered valuable information pertaining to the many strategies or establishments used by participants in order to accumulate their financial resources. Among the participants, a significant proportion mentioned that they did not own any savings. However, a minority of respondents expressed a preference for various savings mechanisms, including banks, NGOs, cooperative societies (samiti), or self-management of funds. This data had the potential to enhance comprehension of people's financial behaviors and decision-making processes, as well as provide valuable insights about the range and accessibility of various savings possibilities within a particular context.

5.28 Communication Improvement after Installation of the Dam

The data suggested that a notable proportion of the participants, namely 14 percent hold the belief that the implementation of the Mohonpur Rubber Dam has led to an enhancement in communication. The participants in this study hold the belief that the construction of the dam had a favorable effect on communication, perhaps through enhancing connectedness, accessibility, and the exchange of information within the vicinity of the dam. The majority of participants, comprising 86 percent of the sample, hold the view that the Mohonpur Rubber Dam had not resulted in enhanced communication.



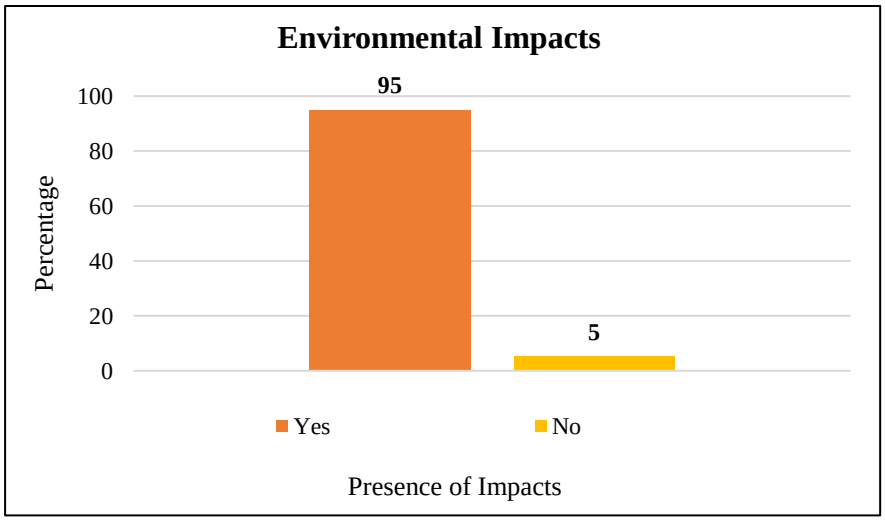
Source: Field Survey, 2023

Figure 28: Communication Improvement

The respondents might not see any discernible beneficial changes in communication patterns or infrastructure as a result of the dam. In essence, the data presented in this study provided insights into the perspectives of the participants about the extent to which the Mohonpur Rubber Dam has facilitated enhanced communication. A minority of participants observed a positive influence on communication, whilst the majority did not observe a connection between the dam and enhanced communication. The provided data had significant value in evaluating the comprehensive impacts of infrastructure initiatives, such as dams, on several dimensions of community existence, including communication.

5.29 Environmental Impacts Due to Mohonpur Rubber Dam

The data revealed that a significant majority of 95 percent of the assessments or evaluations undertaken on the project indicated the presence of environmental consequences, whilst a minority of five percent of the assessments observed the absence of such impacts. The data suggested that a majority of the evaluation results indicated serious environmental implications associated with the Mohonpur Rubber Dam project. The potential consequences included a range of adverse effects on the surrounding ecosystem, biodiversity, water quality, riverbank erosion, and other interconnected environmental aspects like flooding. The data revealed a modest proportion five percent denoting the absence of environmental impacts, showing that a little fraction of the assessment outcomes failed to identify any substantial detrimental consequences on the environment resulting from the project.



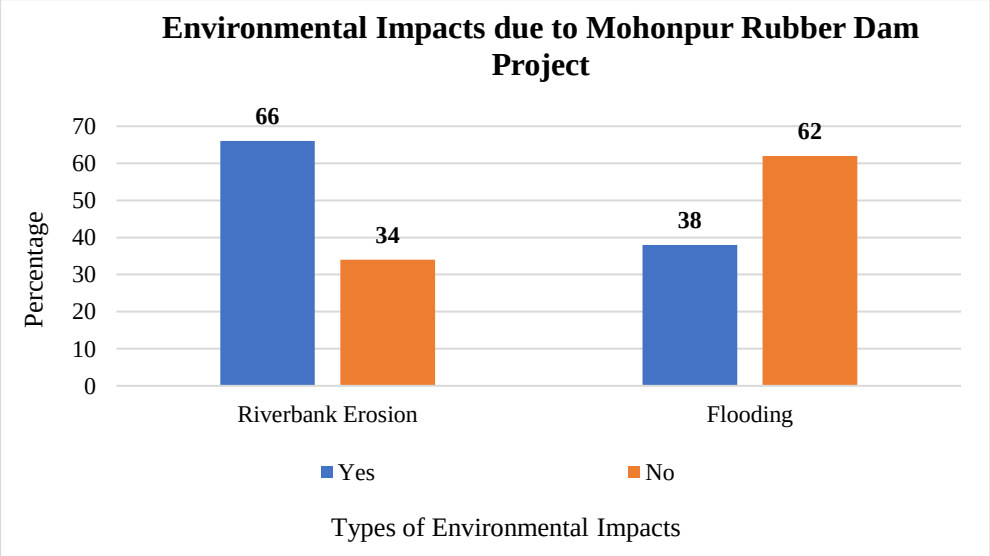
Source: Field Survey, 2023

Figure 29: Environmental Impacts of Rubber Dam

5.30 Environmental Impacts

This finding suggested that in about 66 percent of the respondents, there was evidence or observations indicating the presence of the riverbank erosion as a result of the project. Riverbank erosion is the process through which the banks of a river undergo degradation or wearing away as a result of several variables, including water flow, currents, and environmental influences. Around 34 percent of the evaluations conducted did not provide any substantiated data or observations related to riverbank erosion in connection to the project or condition under evaluation. Moreover, the data indicated that riverbank erosion was more prevalent, as indicated by the majority of evaluations of 66 percent, whereas a smaller proportion of 34 percent that it was not a substantial issue. This finding suggested that around 38 percent of the evaluations revealed indications or observations indicating the presence of the flooding resulting from the assessed project or circumstance. Flooding is the phenomenon characterized by the inundation of water in areas that are typically devoid of moisture, often caused by an abundance of precipitation, the malfunctioning of dams, or other contributing elements.

About 62 percent of the evaluations conducted did not provide any substantiated indications or empirical observations of floods in relation to the project or condition under evaluation. In conclusion, the analysis of the assessments suggested that the occurrence of floods was less probable, as indicated by the majority of the assessments 62 percent while a lesser proportion 38 percent expressed apprehension over its potential impact.



Source: Field Survey, 2023

Figure 30: Environmental Impacts

The survey result depicted the allocation of assessment results according to the specified environmental consequences. According to some of the respondents, a severe flood occurred in 2017 damaging crop fields and houses. People of Dhakail village had to take shelter on the rooftop of Dhakail Government Primary School.

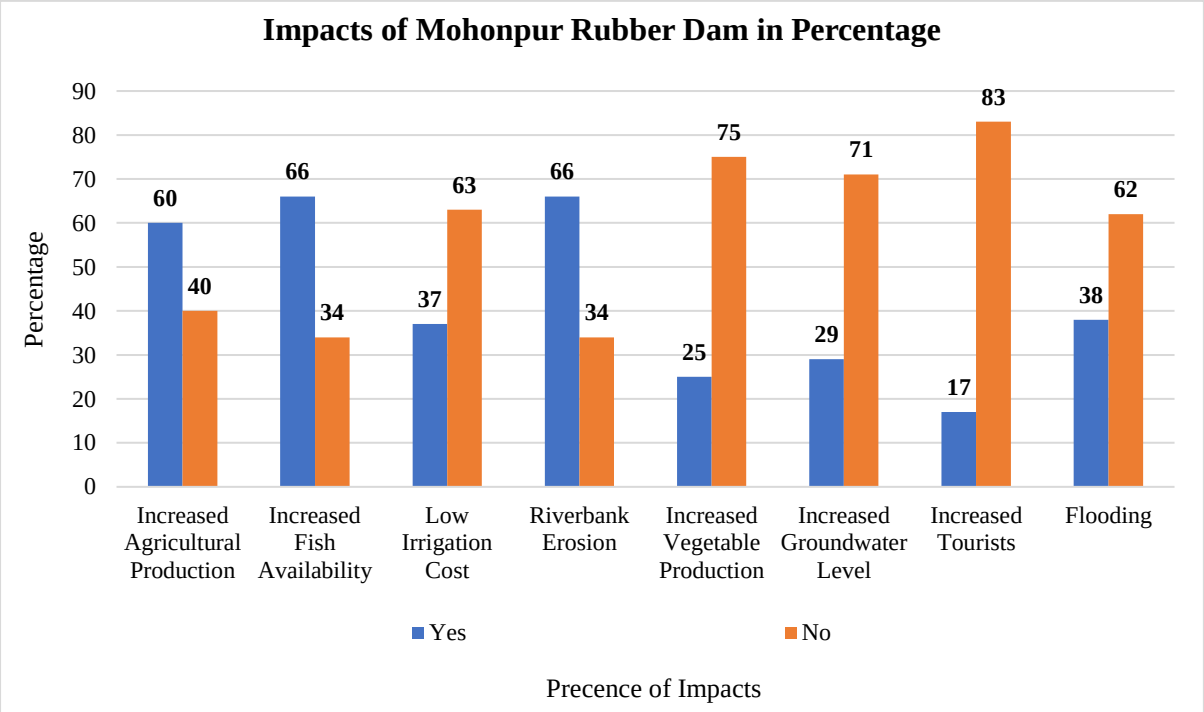
Source: Field Survey, 2023

Photo 5: Riverbank Erosion in the Study Area

5.31 Overall Impacts of the Mohonpur Rubber Dam Project

The Mohonpur Rubber Dam Project has an increase in agricultural production in 60 percent of evaluations. This indicated that the initiative improved agriculture. In 40 percent of evaluations, the initiative had no substantial influence on agricultural productivity. In 66 percent of evaluations, the project has increased fish availability. This suggested that the dam project influenced fish availability. In 34 percent of evaluations, the project did not significantly affect fish availability. In 37 percent of evaluations, the project has reduced irrigation cost. This showed the initiative lowered irrigation expenses. In 63 percent of evaluations, the intervention did not significantly affect irrigation costs. In 66 percent of evaluations, the project had initiated riverbank erosion. In 34 percent of evaluations, the project did not cause substantial riverbank erosion. About 25 percent of evaluations showed that the project increased vegetable production. This suggested the initiative increased vegetable yield. In 75 percent of evaluations, the initiative did not enhance vegetable output. In 29 percent of evaluations, the project increased groundwater level. This implied that the project raised groundwater levels. In 71 percent of evaluations, the project did not raise groundwater levels as per the survey data. The project increased tourists as 17 percent of evaluations. This implied the project increased

tourism. About 83 percent of evaluations showed no substantial increase in visitors attributable to the initiative.



Source: Field Survey, 2023

Figure 31: Impacts of Mohonpur Rubber Dam

In a significant proportion of the evaluations, around 38 percent there existed evidence or observations indicating the presence of the flooding as a result of the project.

Source: Field Survey, 2023

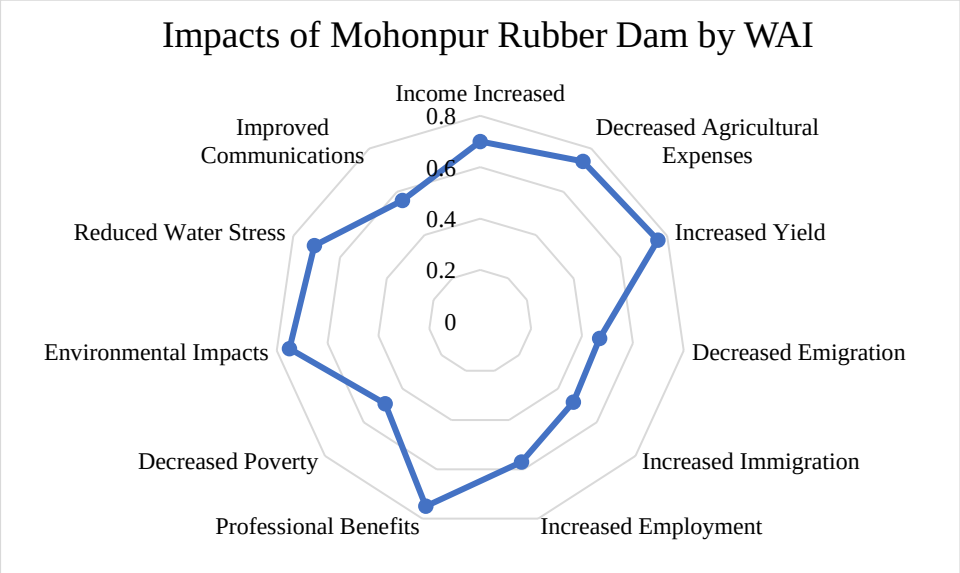
Photo 6: Riverbank Erosion in Dhakail Village

In a majority of the evaluations (62 percent), there was an absence of evidence or observation indicating considerable flooding resulting from the project.

Table 7: Impacts of Mohonpur Rubber Dam Project in Weighted Average Index (WAI)

Impacts	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	N=135 WAI	OA
Income Increased	0.7	12.6	37.8	33.3	15.6	0.70	M
Decreased Agricultural Expenses	5.2	7.4	8.1	71.1	8.1	0.74	M
Increased Yield	5.2	5.2	6.7	70.4	12.6	0.76	M
Decreased Emigration	34.1	3	58.5	4.4	0	0.47	L
Increased Immigration	31.9	0.7	60.7	6.7	0	0.48	L
Increased Employment	16.3	8.1	50.4	24.4	0.7	0.57	M
Professional Benefits	5.9	0.7	14.1	69.6	9.6	0.75	M
Decreased Poverty	4.4	53.3	32.6	9.6	0	0.49	L
Environmental Impacts	3	1.5	21.5	64.4	9.6	0.75	M
Reduced Water Stress	0.7	1.5	50.4	38.5	8.9	0.71	M
Improved Communications	10.4	13.3	64.4	11.1	0.7	0.56	M

Note: Strongly Disagree (SD)- 0.2; Disagree(D)- 0.4; Neutral (N)- 0.6; Agree(A)-0.8; Strongly Agree (SA)-1; Weighted Average Index (WAI); Overall Assessment (OA).



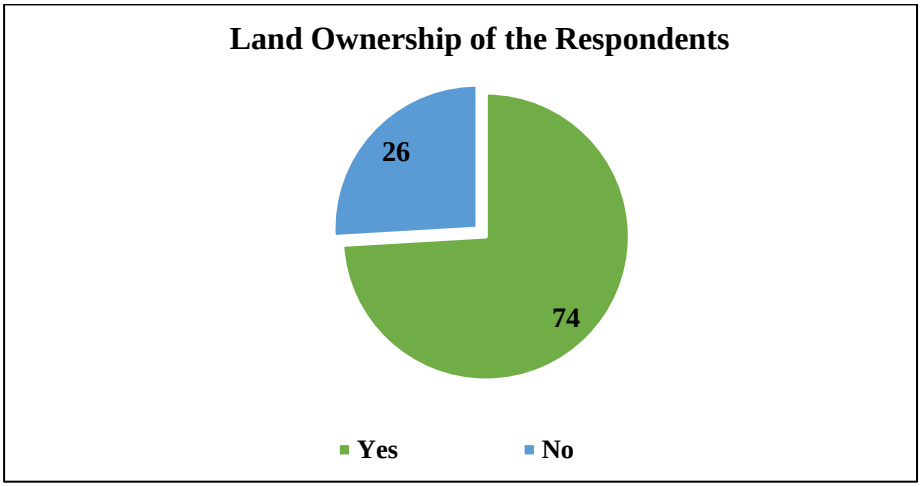
Source: Field Survey, 2023

Figure 32: Impacts of Mohonpur Rubber Dam Project by WAI

The aforementioned percentages provided valuable insights into the allocation of assessment results pertaining to the many consequences associated with the Mohonpur Rubber Dam Project. Each consequence might potentially have distinct repercussions for the environment, local populations, and the overarching objectives of the project. Moreover, respondents were asked if there was any permanent displacement occurred due to the Mohonpur Rubber Dam project. All the respondents answered negatively mentioning no displacement occurred due to the installation of the Mohonpur Rubber Dam Project. Even, the questionnaire also included a query about the unfair political influence over the dam. Local respondents again answered negatively saying they did not observe any political influence regarding the rubber dam project.

5.32 Land Ownership of the Respondents and Amount of Land

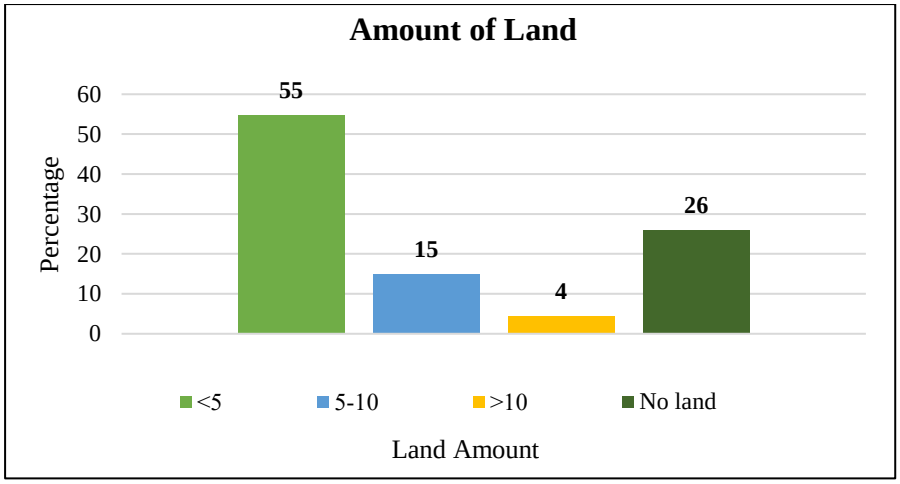
This finding suggested that a majority of the individuals who participated in the survey or evaluation, namely 74 percent of them, classified as landowners. The individuals surveyed exhibited possession or ownership of land. In comparison, around 26 percent of the participants did not own any land. The individuals participating in this study lack possession or control over any real property.



Source: Field Survey, 2023

Figure 33: Land Ownership of the Respondents

Research findings indicated that a significant majority of individuals residing in the research area lack land ownership or own just a little quantity of property. Conversely, several communities within the region possessed a disproportionately large share of land, although being a very tiny fraction of the overall population.

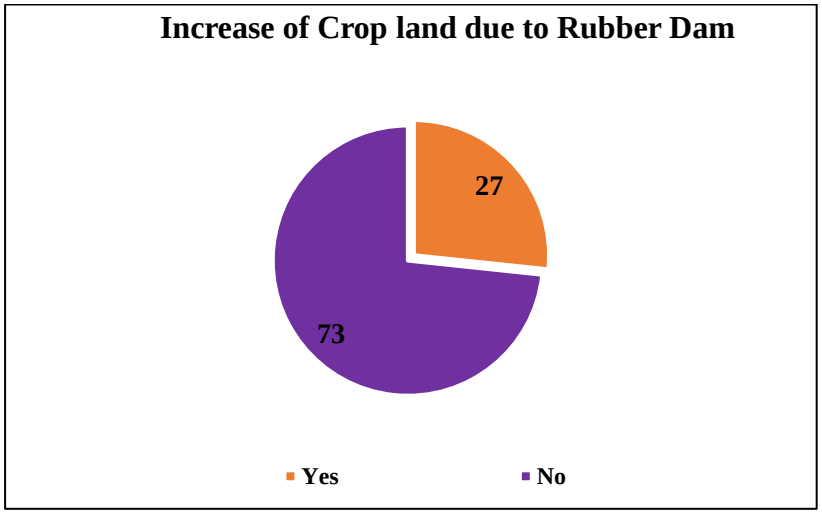


Source: Field Survey, 2023

Figure 34: Amount of Land

5.33 Increase of Crop Land due to Rubber Dam

This finding suggested that about 27 percent of the participants were witnessing or holding the perception that the "Mohonpur Rubber Dam" initiative has led to an expansion of agricultural land. This observation indicated that the participants hold the perception that the implementation of the dam project has resulted in an increase in the use of land for agricultural purposes. of contrast, a majority of around 73 percent of the respondents reported no apparent enhancement of agricultural land as a result of the operation.



Source: Field Survey, 2023

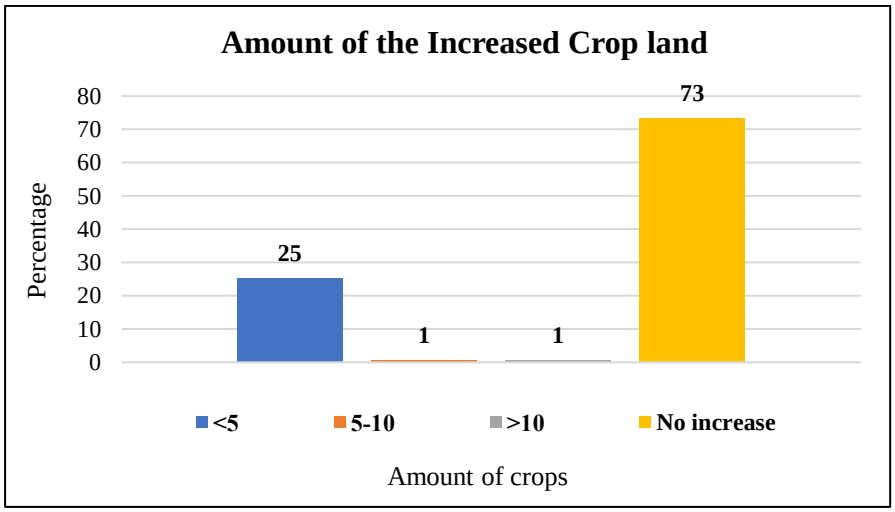
Figure 35: Increase of Crop Land due to Rubber Dam

The respondents hold the belief that the initiative has not yielded a discernible increase in the area of land allocated for agricultural use. Moreover, a minority of participants (27 percent) hold the belief that the "Mohonpur Rubber Dam" initiative has led to an expansion of

agricultural land. The findings indicate that a significant proportion of participants 73 percent did not observe an upward trend in this regard. The provided data illuminated the varying perspectives of people on the influence of the dam project on agricultural activities and land use.

5.34 Amount of Increased Crop Lands

The data suggested that about 25 percent of the participants hold the belief that the "Mohonpur Rubber Dam" project has resulted in a rise of agricultural land measuring less than 5 Bigha (a unit of land measurement). The participants in this study observed a modest increase in the amount of land dedicated to agricultural cultivation. According to some of the respondents, Lands that were previously not under cultivation have become available to cultivate because of the presence of irrigation water at a lower cost. Moreover, lands near the banks of rivers were also now become available to grow different kinds of vegetables along with fruits. Litchi and Mango Farm have noticed an incredible yield after the installation of Mohonpur Rubber Dam.



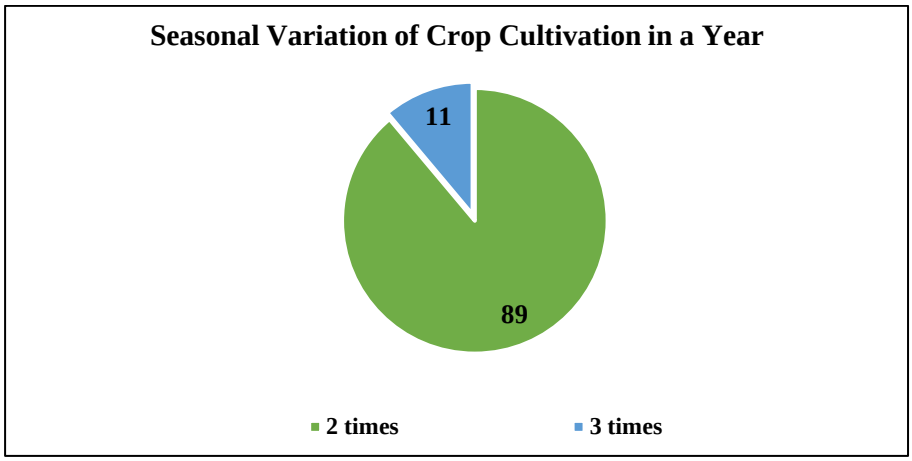
Source: Field Survey, 2023

Figure 36: Increased Amount of Crop Land

5.35 Seasons of Crop Cultivation

Bangladesh has a diverse range of seasons that have an impact on its agricultural practices and crop production throughout the course of the year. The occurrence of these seasons is influenced by the physical position of the area and its closeness to the Bay of Bengal. The

region of north-western Bangladesh undergoes different seasonal variations that significantly influence the timing and outcomes of agricultural agriculture.



Source: Field Survey, 2023

Figure 37: Seasonal Variation of Crop Cultivation

Comprehending these seasonal trends is crucial for the implementation of efficient agricultural planning and management within the area.

This finding suggested that a significant proportion of the participants, namely about 89 percent participate in biannual crop farming. Numerous agricultural locations, such as Bangladesh, often exhibited a dual cropping pattern characterized by a monsoon crop season and a subsequent post-monsoon or winter crop season. The predominant proportion of participants may be categorized as those who engage in agricultural practices throughout these two primary timeframes. On the other hand, around 11 percent of the participants participated in tri-annual crop farming. This implied that a lower proportion of participants may engage in an extra cultivation period, perhaps capitalizing on a wider variety of crops or particular local circumstances that allow a third planting phase.

5.36 Variation and Name of the Seasonal Crops

The North Western area of Bangladesh is characterized by its responsiveness to the cyclical nature of seasons, whereby each season presents distinct agricultural prospects and obstacles. The dynamic relationship between climate, topography, and the Bay of Bengal has a substantial impact on the farming patterns and the assortment of crops that flourish in this particular area. The cyclical patterns of these seasons exert influence on the livelihoods of agriculturalists and contribute to the formation of the environment, resulting in a diverse array of crops that adorn the landscape throughout the course of the year. Bangladesh generally has three agricultural

seasons depending on climate. These are Rabi Crops (Mid-October to Mid-March), Kharif-1 Crops (Mid-March to Mid-July), and Kharif-2 Crops (Mid-July to Mid-October).

These seasons are also popularly known as Pre-monsoon, Monsoon, and Post-monsoon seasons in Bangladesh. Different seasons grow different types of crops according to the climatic conditions, and seasons of Bangladesh.

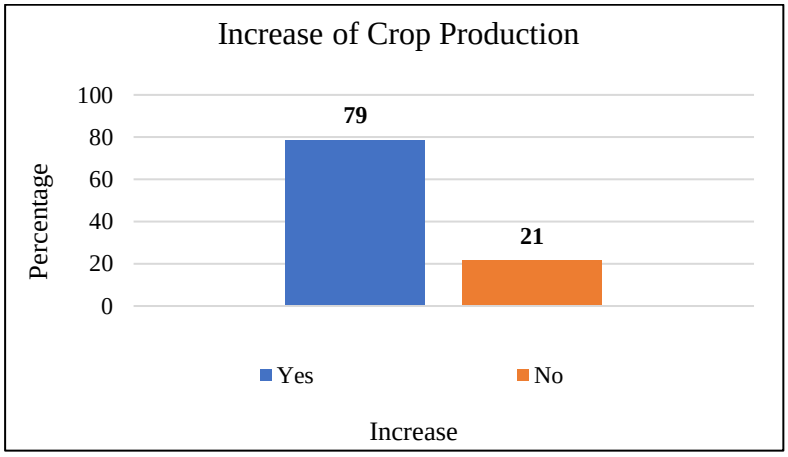
Table 8: Name of the Seasonal Crop Cultivated in the Study Area

Rabi Crops (Middle October-Middle March)	**Kharif-1 (Middle March-Middle July)**	**Kharif-2 (Middle July-Middle October)**
BORO/IRRI (Miniket, Bari-28,29, Hybrid, Chandina, Pari etc.)	Elephant Ear	AMON (Zira-34,90, Basumati etc.)
Maize	Jute	Vegetables
Potato	Lady Finger	
Eggplant		
Mustard		
Pointed Gourd		
Green Chilly		
Wheat		
Tomato		

Source: Field Survey, 2023

5.37 Increase of Crop Production

This finding suggested that an estimated 78 percent of the participants had the belief or had observed a rise in crop yield due to the implementation of the "Mohonpur Rubber Dam" initiative.



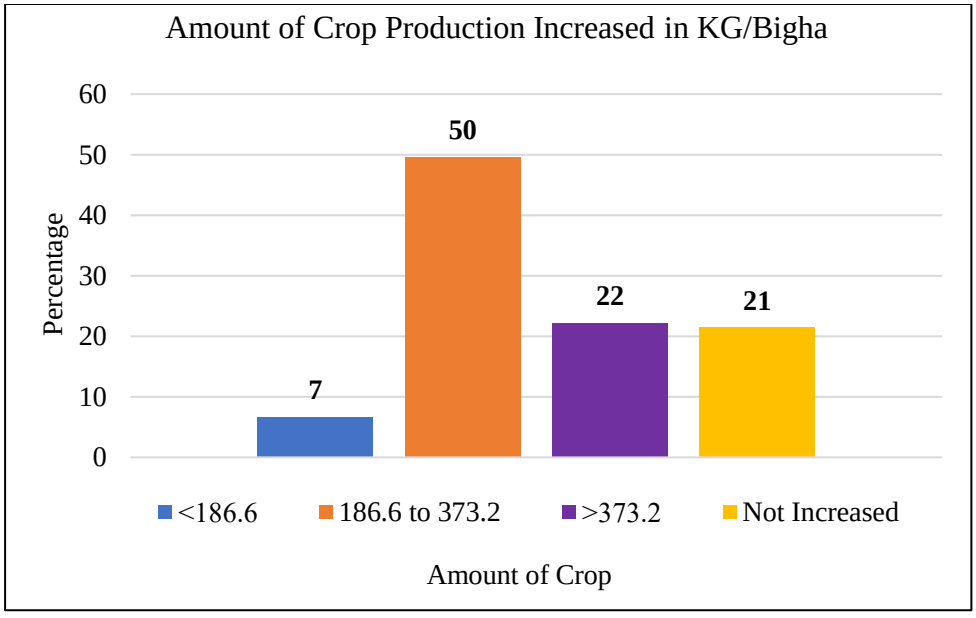
Source: Field Survey, 2023

Figure 38: Increase in Crop Production

The respondents hold the perception that the dam project had a favorable influence on agricultural productivity, leading to increased levels of production. In contrast, around 22 percent of the participants expressed skepticism or reported a lack of empirical evidence regarding any discernible augmentation in crop yield resulting from the initiative. The participants in this study do not report a discernible improvement in agricultural productivity as a direct consequence of the dam initiative.

5.38 Amount of Increased Crop Production

The graphic shown illustrated the distribution of the enhanced crop yield resulting from the implementation of the Mohonpur Rubber Dam Project. This particular group comprised 7 percent of the overall cases. The data suggested that the implementation of the Mohonpur Rubber Dam Project resulted in a marginal increase of less than 186.6 kg per Bigha in crop productivity. The aforementioned group constituted the highest proportion, accounting for 50 percent of the total instances. The data indicated that about 50 percent of the crop yield had a growth ranging from 186.6 to 373.2 kg per Bigha as a result of the initiative. This particular group accounted for 22 percent of the total instances. The findings suggested that a considerable proportion of crop output had a growth beyond 373.2 kilos per Bigha due to the implementation of the Mohonpur Rubber Dam Project. This particular group comprises 21 percent of the total instances.



Source: Field Survey, 2023

Figure 39: Amount of Increased Crop Production

This implied that around 21 of the crop yield did not exhibit any growth in terms of kilos per Bigha as a result of the intervention.

According to several respondents, an increase in crop yield was most prominent in rice cultivation, maize, and potato farming. Farmers mentioned rice production has increased to double in some cases bringing huge profits for both farmers and owners.

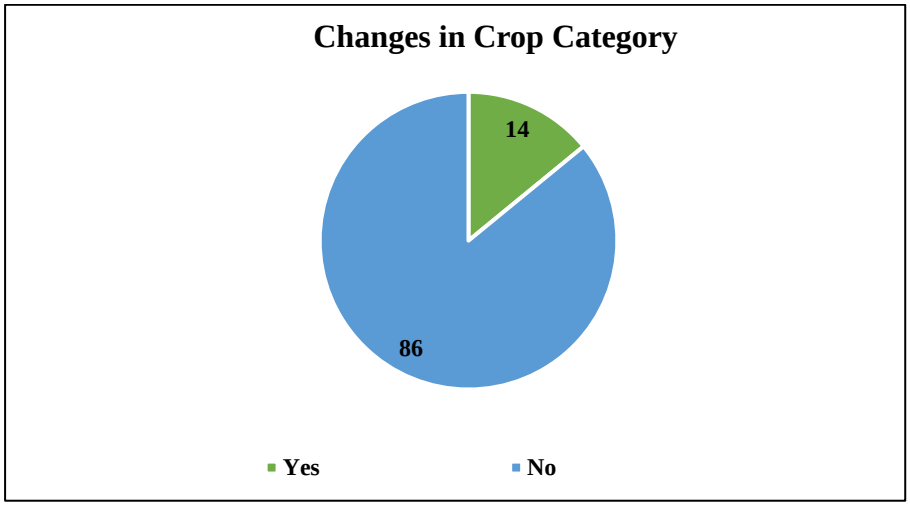
Table 9: Crop Production Scenario Before and After Dam Implementation (Average amount of respondent's response)

Name of the Crops	Present Amount Kg/Bigha (After Dam)	Past Amount Kg/Bigha (Before Dam)
Rice	1557.36 kg	1189.39 kg
Maize	1968.63 kg	1306.2 kg
Potato	2598.59 kg	1637.6 kg
Wheat	933 kg	560 kg
Tomato	3732 kg	1866 kg

Source: Field Survey, 2023

5.39 Changes in Crop Variety

A total of 14 percent of the participants reported observing a shift in crop classification.



Source: Field Survey, 2023

Figure 40: Changes in Crop Category

The data suggested that a minority of participants reported a shift in their crop classification as a result of the Mohonpur Rubber Dam Project. This implied that the participants noted changes in the crops they were farming or the kinds of crops they were producing before to and during the implementation of the project. An addition 86 percent of the participants did not observe

anany kinds of changes. This implied that a significant proportion of participants did not report any discernible changes in their crop category due to the implementation of the study. The respondents maintained the cultivation of identical kinds or categories of crops both before to and subsequent to the implementation of the project.

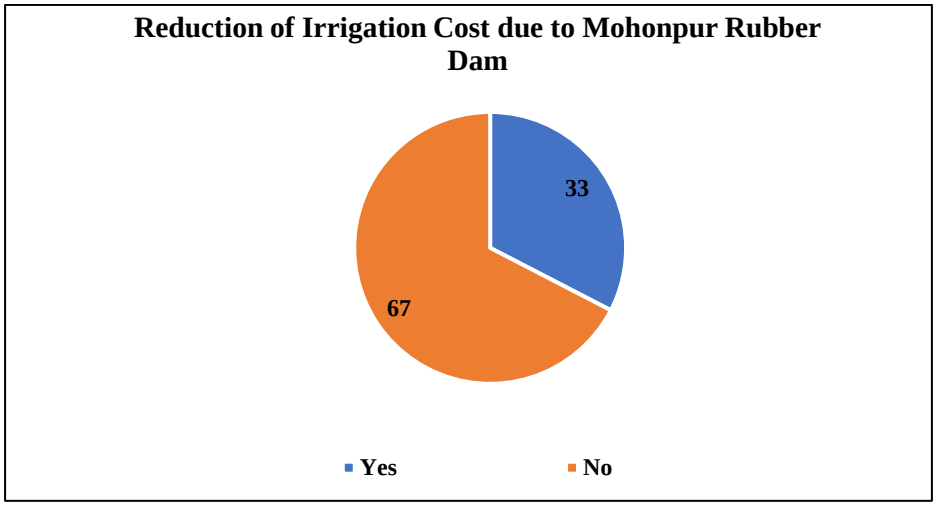
Table 10: Changes in crop variety before and after the implementation of Rubber dam as mentioned by the respondents

Past cultivated Crops (Before Dam)	Presently Cultivated Crops (After Dam)
No crops	Vegetables and fruit trees on the riverbank
Potato, Tomato, Maize, Wheat	Rice
Different types of Coarse Rice	Miniket, Zira Rice, and different demanding rice varieties
Vegetables	Inundated in Water
Single Cropping Lands	Poly cropping lands
Jute	Rice
Wheat	Maize
Local Rice Varieties	HYVs of Rice
No Planned Fruit Garden	Litchi and Mango Garden

Source: Field Survey, 2023

5.40 Reduction of Irrigation Cost

The Mohonpur Rubber Dam Project is a notable infrastructure that supported to improve water resource management and agricultural practices in the area. One of the projected results of the project was the possible decrease in irrigation expenses for farmers in the nearby area.



Source: Field Survey, 2023

Figure 41: Reduction of Irrigation Cost due to Mohonpur Rubber Dam

The examination of this particular aspect had been conducted via the administration of surveys to individuals who have experienced direct impacts resulting from the execution of the project. A representative sample of farmers in the Mohonpur Rubber Dam Project region was surveyed to determine its influence on irrigation cost reduction. The study included irrigation methods and expenses before and after the project. The respondents were asked whether the project reduced their irrigation expenses.

Among the whole pool of participants, it was found that 33 percent of respondents indicated a decrease in irrigation expenses as a direct consequence of the implementation of the Mohonpur Rubber Dam Project. The cost reductions of this set of respondents were ascribed to many sources. The biggest contributing element identified was the dam's capacity to manage water flow and provided a more constant water supply. This technology facilitated the ability of farmers to optimize their irrigation schedules, hence minimizing water loss and reducing the total expenditure associated with irrigation operations. In contrast, a significant proportion of participants, accounting for 67 percent did not indicate a decrease in their irrigation expenses. The selected group presented a range of factors contributing to the absence of apparent cost reductions. It has been suggested that the implementation of a cost-saving technique did not provide positive outcomes for local farmers, mostly owing to the high rate of irrigation.

Source: Field Survey, 2023

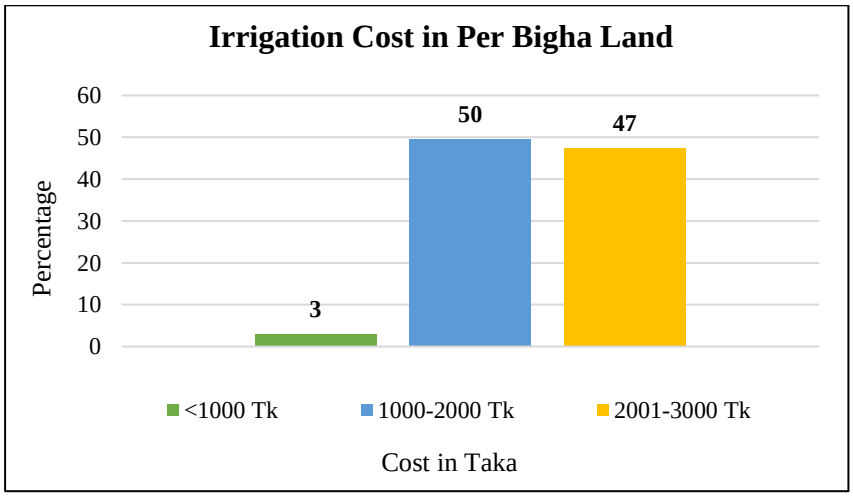
Photo 7: Irrigation Drainage implemented by BADC

Furthermore, the Bangladesh Agricultural Development Corporation (BADC) has established a baseline pricing for the irrigation facility. However, it has come to light that local irrigation leaseholders have subsequently raised the price.

According to a key informant, who is an Assistant Superintendent of Madrasa as well as a local irrigation project leaseholder, told he has to pay BADC Tk. 600 for every acre of land. But, he took Tk. 2000 per 0.33 (One Bigha) acre of land from which he made a profit after giving electricity bills and other operating costs (KII-2).

5.41 Cost of Irrigation in Per Bigha Land

Agricultural irrigation plays a vital role in ensuring sustainable agricultural production, especially in areas where precipitation is inadequate to fulfill the water needs of crops. It is essential for policymakers and farmers alike to possess a comprehensive understanding of the financial implications associated with irrigation techniques. This knowledge was crucial in order to effectively allocate resources and maximize agricultural yield.



Source: Field Survey, 2023

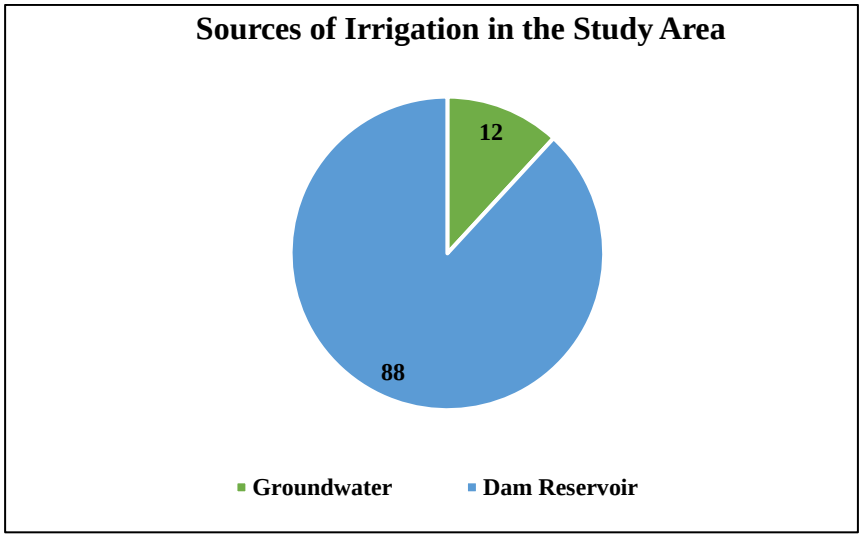
Figure 42: Irrigation Cost in Taka

The group accounts for three percent of the overall participants. Farmers belonging to this particular group claimed that their expenses for irrigation were below 1000 Tk per Bigha of land. This observation suggested the presence of agricultural methods that prioritize limited irrigation or depend on naturally occurring water sources, such as precipitation. The most substantial group consists of 50 percent of the participants. The farmers within this particular cohort have reported a range of irrigation expenses, ranging from 1000 Tk to 2000 Tk per Bigha of land. This finding suggested that a considerable number of farmers allocate modest resources toward using irrigation techniques in order to achieve optimum crop development. This particular group comprises 47 percent of the participants. Farmers lying inside this specified region reported elevated irrigation expenses, ranging from 2001 Tk to 3000 Tk per Bigha. This group was presumably comprised of farmers that use sophisticated irrigation methods or

engage in the cultivation of water-intensive crops that need more irrigation resources. The examination of the expenditures incurred for irrigation of every Bigha of land in the research region highlights the variation in irrigation techniques and the corresponding costs among farmers. While a few of individuals are able to maintain minimal expenses, the majority of individuals allocate moderate to higher levels of investment into irrigation procedures. This research emphasized the significance of comprehending the variables that impact irrigation expenses and emphasizes the need for customized approaches to effectively manage water resources, specifically for crops that require substantial amounts of water or in places that confront water shortage issues.

5.42 Sources of Irrigation

Agricultural irrigation is an essential element in the achievement of effective agricultural production, as it guarantees the provision of sufficient water to crops, hence promoting their optimum development and maximizing their output.



Source: Field Survey, 2023

Figure 43: Sources of Irrigation in the Study Area

Gaining comprehension of the irrigation sources used by farmers within a certain research region is of utmost importance in the formulation of efficient water management plans. The groundwater category comprises 12 percent of the overall responses. Subsequently, these reservoirs provide the regulated release of stored water during arid seasons, primarily for the purposes of irrigation and other related applications. The study region demonstrates the significant function of dam reservoirs in agricultural water management, since they serve as the principal source of irrigation. Reservoirs provide several benefits, including the capacity to

effectively control water allocation, mitigate the impact of drought situations, and furnish a dependable water supply for agricultural irrigation over the entirety of the cultivation period. The prevalence of farmers using dam reservoirs indicates a noteworthy influence on regional water accessibility and serves to enhance agricultural production.

Source: Field Survey, 2023

Photo 8: Water Withdrawal from Dam Reservoir for Irrigation

The potential explanation for the lower proportion of farmers who depend on groundwater for irrigation might be attributed to many variables, including the availability and accessibility of groundwater resources. In some instances, the availability of groundwater sources may be limited, resulting in its predominant use in regions characterized by favorable hydrogeological circumstances. The examination of irrigation sources within the research region reveals that farmers mostly depend on dam reservoirs for their irrigation water supply. This highlights the need of implementing extensive water management infrastructure to facilitate agricultural operations and provide a reliable water supply for crops.

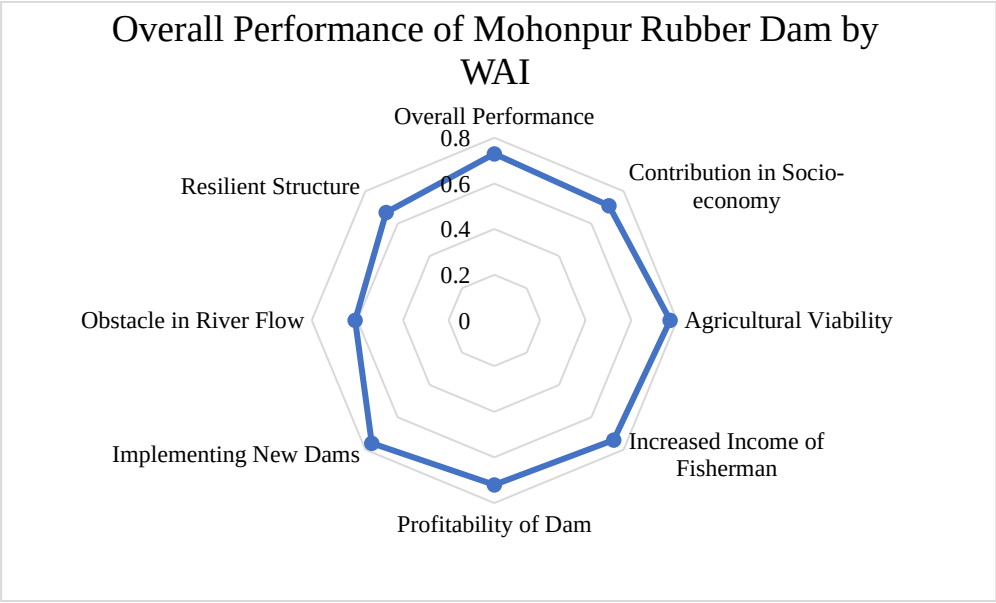
5.43 Performance of Mohonpur Rubber Dam

Interviews were undertaken to examine the overall performance of Mohonpur Rubber Dam Project in order to reflect the viability of the project. Even, the responses of the local people were analyzed in several ways. Weighted Average Index (WAI) was also calculated to demonstrate the overall performance of the project from the perspective of the local affected population.

Table 11: Overall Performance Analysis of the Mohonpur Rubber Dam Project by WAI

Impacts	Highly Unsatisfied	Unsatisfied	Undecided	Satisfied	Highly Satisfied	N=135 WAI	OA
Overall Performance	5.2	6.7	20	55.6	12.6	0.73	M
Contribution in Socio-economy	3.7	6.7	29.6	49.6	10.4	0.71	M
Agricultural Viability	2.2	6.7	11.9	64.4	14.8	0.77	M
Increased Income of Fisher	2.2	7.4	23.7	51.9	14.8	0.74	M
Profitability of Dam	3.7	17.8	11.1	51.9	15.6	0.72	M
Implementing New Dams	0	5.9	23.7	52.6	17.8	0.76	M
Obstacle in River Flow	3	3.7	80	12.6	0.7	0.61	M
Resilient Structure	0.7	5.2	58.5	30.4	5.2	0.67	M

Note: Extremely Unsatisfied- 0.2; Unsatisfied- 0.4; Undecided- 0.6; Satisfied-0.8; Extremely Satisfied- 1; Weighted Average Index (WAI); Overall Assessment (OA).

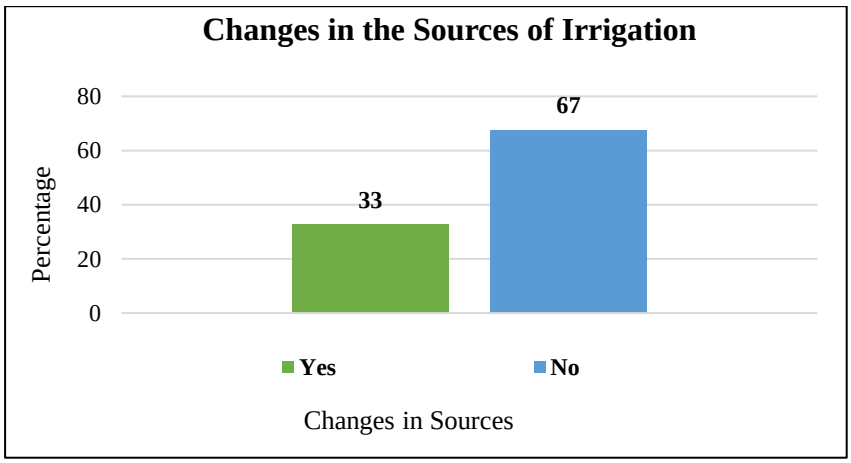


Source: Field Survey, 2023

Figure 44: Overall Performance of Mohonpur Rubber Dam Project by WAI

5.44 Changes in the Sources of Irrigation Due to Mohonpur Rubber Dam

Assessing the adjustments in water resource consumption patterns requires a comprehensive understanding of whether farmers have perceived any changes in their irrigation supplies.



Sources: Field Survey, 2023

Figure 45: Changes in the Sources of Irrigation

The present group constitutes 33 percent of the overall participants. Farmers that responded affirmatively mentioned that they had encountered alterations in their irrigation supplies. This finding indicated that a subset of agricultural practitioners within the examined region have seen changes in their methods of obtaining and using water for the purpose of irrigation. The majority of the responders, namely 67 percent fell into the bigger group. Farmers belonging to this particular group said that they had not seen any changes in their irrigation sources. This suggested that a significant proportion of participants have adhered to a regular watering method using their preferred water sources. The observed alterations in irrigation sources suggest that there have been significant changes in the ways of managing agricultural water in the region under investigation. The affirmative answers may be ascribed to several variables, including fluctuations in water availability, modifications in the regional hydrological cycle, the introduction of water infrastructure initiatives like the Mohonpur Rubber Dam project, or changes in agricultural methods.

The data indicated that a considerable number of farmers have chosen to retain their current irrigation methods, as seen by the percentage of respondents who answered "No." There are other factors that may contribute to this phenomenon, including the stability of pre-existing water supplies, the efficacy of prevailing irrigation techniques, or the absence of substantial changes in regional water accessibility.

Table 12: Irrigation Water Sources Before and After Dam Installation according to the responses of Respondents

Past (Before Dam)	Present (After Dam)
Water Pump (Shallow Machine from Groundwater)	Deep Machine (Dam Water)
River Water by Shallow Machine	Dam Reservoir
Deep Machine (Large Scale)	Dam Reservoir

Source: Field Survey, 2023

Source: Field Survey, 2023

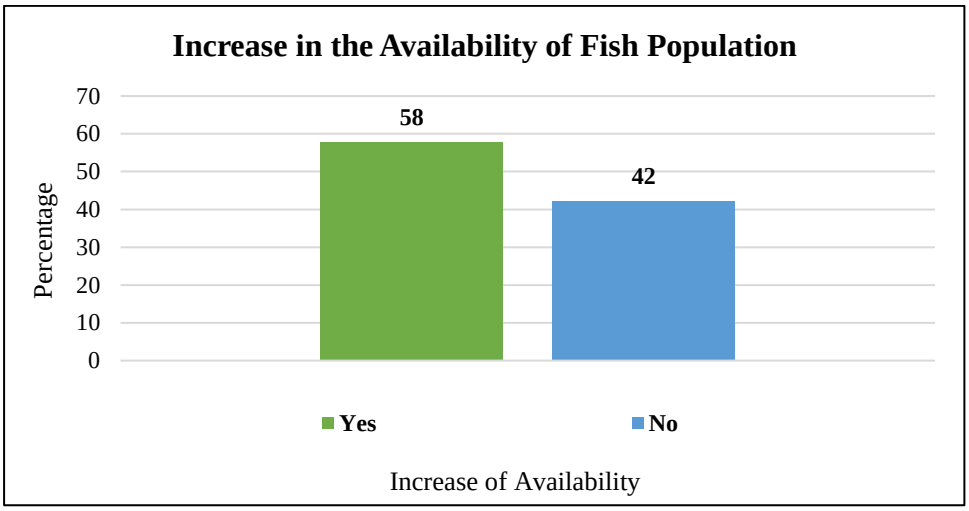
Photo 9: Water Abstraction from Dam Reservoir for Irrigation

5.45 Increase in the Availability of Fish Population

Reservoirs constructed for the purpose of water storage often have diverse effects on surrounding ecosystems, including their capacity to shape the aquatic biodiversity and the abundance of fish communities. It was of utmost importance to ascertain if the existence of a dam reservoir has resulted in a rise in the accessibility of fish. This was essential in order to evaluate the ecological impacts of the reservoir and its possible advantages for nearby populations.

The examination of the survey data elucidated the dispersion of purported augmentations in fish abundance inside the dam reservoir. Respondents who answered affirmatively reported an observable augmentation in the accessibility of fish populations inside the dam reservoir and about 59 percent of the respondents mentioned that. This implied that a notable percentage of

participants have seen favorable changes in the aquatic habitat subsequent to the implementation of the dam reservoir.



Source: Field Survey, 2023

Figure 46: Increase in the Availability of Fish Population due to Dam Reservoir

The remaining group accounted for 42 percent of the participants. Participants belonging to this particular group said that they had not seen any discernible rise in the abundance of fish populations inside the reservoir created by the dam. This suggests that a considerable proportion of participants did not see substantial changes in the availability of fish after the establishment of the reservoir. The observed rise in fish populations in the dam reservoir suggested reservoirs may benefit aquatic ecosystems. Dam reservoirs generated new habitats and modify hydrological conditions, affecting fish populations. Improved water quality, habitat variety, and fish breeding and growth conditions may boost fish supply. Pre-existing fish populations that were unaffected by the dam reservoir, varied ecological conditions throughout the reservoir, or other factors affecting fish behavior and dispersion may explain this.


Source: Field Survey, 2023

Photo 10: Fishers Catching Fish in the Dam Reservoir

5.46 Some Additional Issues

Table 13: Some Additional Issues according to the responses of Respondents

Issues	Responses of the Respondents
Permanent Displacement Due to the Installation of the Mohonpur Rubber Dam Project	No Displacement Occurred
Political Influence over Rubber Dam	No Political Influence Observed
Uses of Fertilizer in the Crop Land	Yes
Types of Chemical Fertilizer typically used in the Crop Land	Urea, Triple Super Phosphate (TSP), Potash, Diammonium Phosphate (DAP), Gypsum, Various Vitamins, and several types of Pesticides etc.
Reduction of Using Chemical Fertilizer After the Implementation of Rubber Dam	Not Reduced
Paying Illegal Money for Using Water from Dam Reservoir	Have not to pay any money illegally for using dam water for personal uses

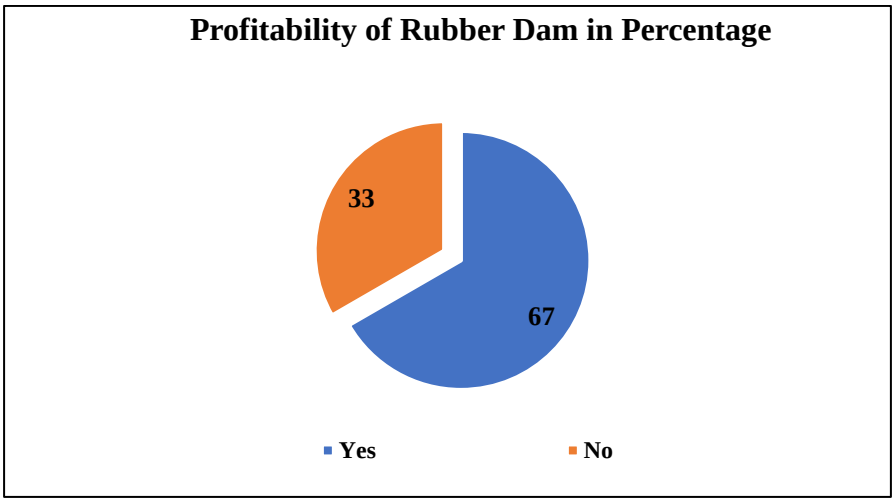
Source: Field Survey, 2023

5.47 Profitability of Rubber Dam

The implementation of rubber dam projects signified a substantial allocation of resources toward the development of water management infrastructure. The assessment of the profitability of these initiatives had significant importance in determining their economic implications on local populations. The analysis of reported profitability was conducted by considering various variables, including the enhanced income of beneficiary groups,

employment opportunities for families, enhanced crop production, increased availability of fish, alterations in crop production, fluctuations in irrigation costs, shifts in sources of irrigation, and other factors that could potentially impact the economic outcome of the rubber dam project. The research sought to examine the relationship between several variables and the perceived profitability of the rubber dam by combining these elements.

The examination of the survey data revealed the distribution of the stated profitability of the rubber dam across the participants. Indeed, the aforementioned group constitutes 67 percent of the overall participants. Participants who responded affirmatively reported seeing the rubber dam as advantageous. This finding indicated that a considerable majority of participants hold the belief that the rubber dam project's economic advantages surpass the related expenses.



Source: Field Survey, 2023

Figure 47: Profitability of Rubber Dam

The remaining group accounted for 33 percent of the participants. Participants belonging to this particular group mentioned that they did not consider the rubber dam to be advantageous. This suggested that a significant proportion of participants maintain the viewpoint that the initiative has not resulted in beneficial economic benefits. Multiple variables affect the rubber dam's profitability. Some indicated better agricultural productivity, lower irrigation costs, improved water availability, and water resource management. All of these variables affect profitability perception. Another group indicated that some respondents did not consider the rubber dam project economically feasible. This might be owing to unforeseen implementation issues, lack of intended outcomes, or a feeling that benefits did not exceed expenses. A considerable number of responders thought the initiative was profitable, while some disagreed.

5.48 Correlation among Variables

Correlation Matrix among several variables reflects various strengths of relationships among the variables. The matrix showed that no relationship between increase of yearly income and family employment opportunity existed.

It means both variables are uncorrelated. The first variable is uncorrelated with the communication improvement. But, the increase of yearly income of respondents had a weak but significant correlation with the variable reduction of irrigation cost. Moreover, the first variable expressed a strong significant correlation with poverty reduction. It implied an increase in the income of respondents cooperates to reduce poverty among the respondents. Reduction of irrigation costs helped to increase the yearly income of respondents by making agriculture more profitable for farmers. Family employment opportunity also demonstrated a significant correlation with Poverty reduction.

Table 14: Correlation Matrix among Variables

		1	2	3	4	5	6	7	8
1	Increase of Yearly Income								
2	Family Employment Opportunity	-.04							
3	Communication Improvement	.1	-.06						
4	Increase of Cropland	.06	.201*	.189*					
5	Increased Crop Production	.04	.11	.06	.15				
6	Reduction of Irrigation Cost	.480**	-.01	.173*	.188*	.06			
7	Availability of Fish	.11	.02	-.04	.01	.356**	.11		
8	Poverty Reduction	.505**	.258**	.12	.11	.12	.197*	.307**	

Note. N = 135. *p < .05; **p < .01

This means family employment opportunities cooperate to reduce poverty among the respondents. The variable also expressed a relationship with the increase of cropland. The

increase in cropland creates more job opportunities among the respondents opening a door for the unemployed to get employment. Communication improvement showed a relationship with two other variables, which are the increase of cropland and the reduction of irrigation costs. Agricultural profitability provides the motivation to cultivate more lands, increasing the amount of cropland. Increased crop production has a correlation with a reduction in irrigation costs. Reduction of irrigation costs allows the farmers to invest more in the lands resulting to increase crop production. Even, it has a strong relationship with the increase of croplands. The other variables also express different kinds of correlation among themselves making inter-connected variables to evaluate the internal influences.

5.49 Theoretical Calculations

5.49.1 Command Area Efficiency (CAE)

Command Area Efficiency of Mohonpur 5 cusec Scheme and Bhabki Scheme of the Mohonpur Rubber Dam Project are tabulated in Table (14). Command area efficiency relied largely upon irrigated areas and potential irrigated areas. Potential irrigated areas are the areas that can be brought under irrigation facilities of a certain scheme. Actual command area depends on a wide variety of factors like farmer's irrigation involvement, cultivation interests, timely maintenance of drainage systems, favorable soil status, efficient water management practices, methods of irrigation, etc. The lower command area efficiency occurs due to lower discharge from the rubber dam reservoir, water losses due to poor drainage facilities from the conveyance system, and poor water management practices for irrigation activities.

Table 15: Command Area Efficiency (CAE) of Mohonpur Rubber Dam Project

Serial No.	Name of the Irrigation Schemes	Irrigated Area, (ha)	Potential Command area, (ha)	Command Area Efficiency, (%)
1	Mohonpur 5 cusec LLP Scheme	161.874	445.15	36.36
2	Bhabki Scheme	161.874	323.75	49.9

Source: Field Survey, 2023

According to the calculations of Command Area Efficiency (CAE), the performance of Mohonpur 5 cusec LLP Scheme is comparatively low, while the performance of Bhabki

Scheme is pretty well. But, the potential irrigated areas for both schemes are very high. Planned actions can help to expand the services of dam reservoirs for cultivating crops. There are already 4970 meters long drainage facilities available for Mohonpur scheme implemented by BADC. The Mohonpur Scheme provides irrigation facilities in two villages which are Mohonpur and Parameshwarpur. Expansion of drainage facilities can provide a huge benefit for the farmers of Parameshwarpur village. Even, according to FGD-1 information, if BADC can install 400 feet canal (drainage facility) connecting Parameshwarpur to Lokkhitola water reservoir pond (Locally known as Khari), the people of Lokkhitola village will also be benefited from the dam reservoirs.

On the other hand, the new installation of a drainage canal for Bhabki Scheme can provide massive irrigation facilities to the Amtoli area where currently people are completely dependent on Deep Machines (DM) for crop cultivation. So, both schemes have a very huge prospect in providing irrigation facilities to locally inhabited people.

5.49.2 Irrigation Efficiency (IE)

The total demand for water of crop season 2022-23 was calculated using the popular software CROPWAT 8.0 developed by Food and Agriculture Organization (FAO). Climatic and Meteorological data were collected using CLIMWAT 2.0 software developed by FAO. For extracting climatic and meteorological data, Dinajpur stations were selected. Water discharge data was collected from Bangladesh Water Development Board (BWDB). For extracting data with accuracy Bushirbandar station was selected which is located in Karatoa-Atrai River with SW 142.1.

Table 16: Calculation of Net Irrigation Requirement of Crop

Month	Etc (mm)	Effective Rainfall, Re (mm)	NIR= ETc-Re (mm)
September	106.1	21.6	84.5
October	113.5	26	87.5
November	162	6.1	155.9
December	90.4	0	90.4
Total			418.3

Source: CROPWAT 8.0 Software

For Mohonpur Rubber Dam Project, (Equation-1) Total supply of water (in depth) = (Total discharge water/ Total irrigated land)

= (589939200 m^3 ÷ 800×10^4 m^2) = 73.74 m

So, (Equation-2) Irrigation Efficiency = $\frac{0.4183m}{73.74m} \times 100$

= 0.57%

By using equation-2, the Irrigation Efficiency (IE) is 0.57%. Depending on the result it can be said that the irrigation efficiency of the Mohonpur Rubber Dam Project was very low.

5.49.3 Benefit-Cost Ratio (BCR)

Benefit-Cost Ratios (BCRs) of both schemes of the Mohonpur Rubber Dam Project are comparatively good for the case of land owners who do not have to pay any kind of money. So, they are the most beneficiary groups in rice cultivation. Even, the study suggests most of the people in the study area do not own cultivable lands except their houses. While only a few people held a huge amount of land ownership keeping the landless people dependent on them for their survival. According to the findings of the investigation, landless people have to rely on leasing a unit of land for an amount of money for a year. The temporary lease money varies from village to village. The amount is often determined by the demand for lands and the productive capacity of the specific lands. As our research was limited to three villages, we have identified the temporary lease money for the lands in the villages. However, due to HYVs of rice production, local farming is profitable now which was not economically viable before.

Table 17: Temporary Lease Money (Locally known as "Khaykhelashi" of three villages with the causes of variation according to the opinion of respondents

Name of the Village	Temporary Lease Money or "Khaykhelashi" (Tk/Bigha/Yearly)	Causes of Variation
Parameshwarpur	25000-30000	Less Productive and Less Demand for Lands
Dhakail	40000	Highly Productive and High Demand due to huge population density

Bhabki	30000	Highly Productive but less demands as a good percentage of residents own cultivable lands.

Source: Field Survey, 2023

Though, BCR is quite less for landless people as they have to pay a good amount for temporary lease money. The landless people adapt to the situation in a way that everybody cultivates a good amount of land. According to the survey report, it can be said that maximum landless people cultivate at least 3-4 bighas of land in order to gain a good return for survival. Reduced Irrigation costs initially reduced their total costs for cultivation but the current mounting of fertilizer and oil prices have again led to the reduction of net return from the lands reducing profits for farmers.

Table 18: Performance of Benefit-cost ratio of Schemes of the Mohonpur Rubber Dam Project (BCR for Land Owners as they don't have to pay lease money)

Serial No.	Name of the Irrigation Scheme	Total Cost (Tk./ha)	Gross Return (Tk./ha)	Net Return (Tk./ha)	Benefit-Cost Ratio
1	Mohonpur 5 cusec LLP Scheme	45000	105000	60000	2.3
2	Bhabki Scheme	38395	95500	57105	2.49

Source: Field Survey, 2023

Table 19: Performance of Benefit-cost ratio of Schemes of the Mohonpur Rubber Dam Project (BCR for Landless farmers as they have to pay lease money to land owners)

Serial No.	Name of the Irrigation Scheme	Total Cost (Tk./ha)	Gross Return (Tk./ha)	Net Return (Tk./ha)	Benefit-Cost Ratio
1	Mohonpur 5 cusec LLP Scheme	75000	105000	30000	1.4
2	Bhabki Scheme	68395	95500	27105	1.39

Source: Field Survey, 2023

5.49.4 Yield Efficiency (YE)

According to the farmers of the Mohonpur Rubber Dam Project, the actual yield in the Boro season was 6660.108 kg per hectare. But from the feasibility report, the target yields are 7086.45 kg per hectare. The calculations suggest that 93.98% of Yield Efficiency is pretty good meaning the performance of the Mohonpur Rubber Dam Project is really well in acquiring the targeted yields. The performance is very close to the target. But, another factor needs to mention here, the uses of fertilizers are very high in the study region. So, it is quite difficult to express the actual performance-oriented increase of yield in the dam area.

Table 20: Yield Efficiency (YE) Calculation

Project	Actual Yield (Kg/ha)	Target Yield (kg/ha)	Yield Efficiency (YE)
Mohonpur Rubber Dam Project	6660.108	7086.45	93.98%

Source: Field Survey, 2023 & Target reports of the Project.

5.50 Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) Information

Table 21: Information (Dominant Group) Collected from KIIs and FGDs

Factors	Results derived from KIIs and FGDs	Sources
Education	Primary and Lower Secondary	KII-2, KII-3, FGD-1, FGD-3
Changes in Profession	Shifted to Agriculture, Shopkeeper, and Van Puller	KII-1, KII-2, FGD-1, FGD-2, FGD-3
Increase in Annual Income	Increased	KII-1, KII-2, FGD-2, FGD-3
Decrease of Poverty	Decreased	KII-1, KII-2, KII-3, FGD-2, FGD-3
Employment Opportunity	Increased in Agriculture and Rice Mills	KII-1, KII-2, FGD-1, FGD-2, FGD-3

Political Influence over Dam	No Influence	KII-1, KII-3, FGD-1, FGD-2, FGD-3
Migration	Low	KII-2, KII-3, FGD-1, FGD-2, FGD-3
Ownership of Land	Few People own much of the lands	KII-1, KII-3, FGD-1, FGD-2, FGD-3
Increase of Crop Lands	Increased	KII-1, KII-2, FGD-2, FGD-3
Increase in Yield Production	Increased	KII-1, KII-2, KII-3, FGD-2, FGD-3
Reduction of Irrigation Costs	Reduced in comparison with DTWs	KII-1, KII-2, FGD-1, FGD-2, FGD-3
Changes in the Sources of Irrigation Water	Changed to Dam Reservoir	KII-1, KII-2, FGD-1, FGD-2, FGD-3
Fish Availability	Increased due to favorable breeding condition	KII-1, FGD-3

Source: Field Survey, 2023

Table 22: Performance Constraints and Resulting Problems of the Mohonpur Rubber Dam Project

Constrains/Impacts	**Results derived from KIIs and FGDs**	**Sources**
Village Conflicts	Villages conflicts arose between Parameshwarpur and Bhabki regarding a Samiti (Formed to catch fish off the Dam Reservoir). Each Villages's Samiti consists of 400 members responsible to collect and consume the fish of the reservoir.	KII-2, KII-3, FGD-1, FGD-3

Riverbank Erosion	Extreme riverbank erosion on both sides of the rivers. The most vulnerable area lies within Dhakail village. The situation is getting worse day by day.	KII-2, KII-3, FGD-1, FGD-2, FGD-3
Reduction of Fish Population	Due to the barrier in the natural flow of the river, the availability of fish population has reduced significantly.	KII-2, KII-3, FGD-1, FGD-2, FGD-3
Flooding	Floods often occur due to the impediment in the natural flow of rivers. In 2017, a disastrous flood was experienced by the locals	KII-1, KII-2, FGD-1, FGD-2, FGD-3
Dredging	Dredging in the river resulted in an increase of riverbank erosion	KII-2, KII-3, FGD-2, FGD-3

Source: Field Survey, 2023

However, all the key informants and FGDs recommended implementing an embankment along the bank of rivers in order to stop riverbank erosion. If the embankment is not built soon, the river will wash away a huge portion of land leaving local people landless. Building an embankment will allow them to extract more benefits from the Mohonpur Rubber Dam Project.

Chapter 06: Conclusion and Recommendations

6.1 Introduction

This chapter provided a brief overview of the entire study, including its goals and conclusions. Additionally, it allowed the researcher to assess the overall significance of the research findings and determine what initiatives need to be taken in order to minimize the losses. At the end of this chapter, there is also some advice for future researchers interested in conducting similar research, which mainly highlights any research gaps or unresolved issues that were encountered throughout this study. Moreover, this chapter also demonstrated the actual scenario of the project based on the responses of the respondents and other informants.

6.2 Summary of the Research

Being a densely populated agro-based country, Bangladesh heavily depends on its local crop production for sustaining its huge population. The government of Bangladesh also seeks to ensure food security by increasing the local productivity of farmers and lands. Thus, several structures were introduced in order to support local farming, so that they can highly contribute to the national production budget. To meet the food demand of the growing population, various types of HYVs were introduced in Bangladesh, which also enhanced the demand for irrigation. Farmers significantly rely on groundwater for irrigation for cultivating rice in the Boro season. Due to the origin of such HYVs, farmers need to over-extract groundwater. The situation is even worse in the northwestern region of Bangladesh because of the unavailability of water resources. Extra pressure on the groundwater table leads to the depletion of the groundwater level, which was also affected by irregular rainfall posing difficulty in groundwater rechargeability. As the northwestern region is extremely fertile in cultivating various crops, farmers are bound to irrigate the farmlands using water from a ground source. Thus, excessive pressure in groundwater sources and irregular rainfall combined posed serious threats to the environment.

However, the government of Bangladesh adopted an initiative in order to shift the uses of water from groundwater sources to surface water sources, anticipating to reduce pressure on groundwater table. As part of this initiative, the Mohonpur Rubber Dam Project was implemented in Dinajpur district to supply irrigation water from surface water sources. Rubber Dam is one kind of water retention structure built for multivarious objectives. The structure

primarily facilitates in local irrigation process, reduces flooding, improves groundwater levels, and cooperates in fish breeding. The rubber dam structure became familiar after the 1950s in the countries like China, Japan, Taiwan, and the USA. Bangladesh first commissioned a rubber dam project for supporting the local irrigation process in 1995. In line with this initiative, the country has now approximately 30 rubber dams in operation implemented by LGED, BWDB, and BADC.

Dinajpur is well known for its various kinds of rice variety. Thus, dependency on groundwater has become even more severe in these regions for supporting the production of famous rice varieties. This leads to the serious depletion of groundwater levels in the different parts of the district. Study suggests, groundwater served as the primary source of irrigation for more than 97 percent of the nation's total irrigated land, which constituted around 85 percent of the net cultivable area. Notably, the Northwest (NW) region accounted for a significant proportion of this overall groundwater utilization. The Mohonpur area which is selected for investigation, is located on the bank of the Atrai River and is highly appropriate for producing different kinds of crops especially famous rice varieties. For groundwater extraction, the farmers of the region installed several deep machines. But, the Atrai River could be a reliable source of irrigation in the dry season without posing threats to the groundwater table. Thus, LGED implemented the dam in 2014, and since then the dam is facilitating the irrigation system of the region. The Mohonpur Rubber Dam project was selected for investigation in order to determine the agricultural and socioeconomic impacts of the dam as well as to evaluate the performance of the dam. The mixed method research was adopted to conduct the study emphasizing quantitative data.

The dam is inflated in the dry season and remained for four months retaining water for irrigational purposes. BADC implanted irrigation schemes and introduced drainage facilities to provide irrigation water to nearby arable lands. Investigations reflected mixed results from the respondents. As the three villages were chosen to study, the villages have different opinions regarding the rubber dam projects' impacts. The main profession in the study area was farming accounting for almost 57 percent of the total respondents marking the agricultural dependency of the people. Primary and lower secondary education accounted for the maximum percentage, while the higher education percentage was very low. Nuclear families were dominant in the study area with members of 3-4 people. Professional dynamism was low consisting of one-fourth of the total respondents. Several respondents shifted to becoming farmers as farming was considered to be profitable in the study area. After the implementation of the Mohonpur

rubber dam project, agriculture became more profitable than it was before due to the reduction of costs and high-yield productivity. The migration percentage was very low, while Dinajpur City was considered to be the most anticipated destination for most of the respondents. Mohonpur Rubber Dam increased the income of the respondents through various means such as increased yield production, reduced irrigation costs, the arrival of tourists, communication improvement, and increased availability of fish.

The agricultural variables demonstrated positive impacts increasing the productivity of the lands, reducing costs, cultivating HYVs, and making agriculture economically more viable. Even, the installation of the rubber dam has affected the local crop variety introducing several new crop varieties in the study area. The production of rice has increased by almost 400 kg as timely irrigation facilities were possible due to the construction of the Mohonpur Rubber Dam Project. Approximately 62 percent of the total respondents were informed about the reduction of the poverty rate creating a developing status. Even, 90 percent of the respondents used water from the dam reservoir reducing pressure on the groundwater table. However, it was evident from the survey that, rubber dam technology was extremely beneficiary for agricultural uses in the study area. Among all the local residents, most of the people were affected severely by riverbank erosion posing a serious impact created by the rubber dam projects. Flooding was also observed by several respondents mentioning the devasting experience of a flood that occurred in 2017. Stopping illegal dredging, and establishing an embankment along the bank of the river could reduce riverbank erosion. Early Warning Systems (EWS) and proper deflation of the rubber dam are also significant for alleviating the impacts of flooding.

Theoretical calculations also provided mixed results indicating some performance barriers in the operation of the Mohonpur Rubber Dam Project. Command Area Efficiency (CAE) resulted in a positive scenario in Bhabki Scheme accounting for 49.9 percent, but an improvement was necessary in Mohonpur Scheme, which accounted for 36.36 percent. Irrigation Efficiency (IE) reflected an average result for both schemes accounting for 0.57 percent. Benefit Cost Ratio (BCR) also reflected mixed results marking Bhabki Scheme as more standard than Mohonpur Scheme. Benefit-cost ratio of Bhabki Scheme accounted for 2.49 percent whereby Mohonpur Scheme resulted 2.3 percent. Yield Efficiency (YE) reflected a standard result mentioning the current crop production was very close to the estimated crop production which was 93.98 percent.

6.3 Recommendations

1. An embankment should be built immediately along the banks of rivers to reduce the riverbank erosion in the study area.

2. Several respondents have lost their valuable land property to riverbank erosion, financial support needs to be disbursed among them.

3. The costs of irrigation must be reduced for marginal farmers so that they can get appropriate benefits from the project.

4. Rubber Dam remained in operation only for four months, which is insufficient for many farmers. So, the operation time of the rubber dam should be extended.

5. If technical problems are observed, it took several days to repair. The repairing task should be completed immediately.

6. Early Warning System (EWS) must be developed and made effective in the area so that they can prepare and adapt to the crisis.

7. Illegal dredging works should be stopped immediately in order to reduce riverbank erosion.

8. More drainage channels should be installed as per the requirements of the marginal farmers.

9. An initiative should be taken by the local authority for releasing small fish in the dam reservoir so that local fishers get maximum benefits.

10. Conflict between villages should be solved regarding fishing.

6.4 Conclusion

The research was a basic investigation regarding the impacts of the Mohonpur Rubber Dam Project on agriculture and the socio-economy of the local people. Four theoretical calculations were also undertaken in order to evaluate the performance of the dam. The investigation found that a strong impact prevailed on agriculture and socio-economy. After the installation of the dam, agricultural production has increased, costs have reduced, HYVs of crops came into practice, and overall agriculture has become economically more profitable. The dam created an opportunity for family members to get employment due to the tourist arrival. Income increased significantly, poverty was reduced, communication improved, and decreased migration rate reflect the improving situation of the local socioeconomic status. However,

riverbank erosion and flooding became more frequent than before, leading to the loss of land property. Theoretical calculations posed mixed results regarding the performance of the dam marking a clear improvement that can be made in terms of its overall performance. The overall impacts of the dam have been discussed. Since this study was a socioeconomic survey, it is hoped to contribute to knowledge regarding the issue and assist to understand the benefits and problems of rubber dam projects and their economic viability. Apart from that, the resulting positive and negative impacts can be significant for both policymakers and academics for further investigation and setting up a similar structure in different regions.

References

Ahmed, F., Hridoy, Z. A., & Miah, M. M. (2020) A comparative study on Menongchara and Buraghat rubber dam projects in Mymensingh.

AlKhafaji, H., Muttashar, W. R., & Al-Mosawi, W. M. (2023). Proposing an inflatable rubber dam on the Tidal Shatt Al-Arab River, Southern Iraq. *Journal of the Mechanical Behavior of Materials*, *32*(1), 20220201.

Azizul Hoque, S. M. (2010). *Performance evaluation of pekua rubber dam at Cox, s Bazar*, BUET.

Bangladesh Bureau of Statistics, (2013). District Statistics 2011 Dinajpur.BBS.www.bbs.gov.bd.

Bao, L., Li, X., & Su, J. (2020). Alteration in the potential of sediment phosphorus release along series of rubber dams in a typical urban landscape river. *Scientific Reports*, *10*(1), 2714.

Blair, A. A. C. (2017). Climate change threats and adaptation responses in small island developing states: A comparative analysis of Antigua & Barbuda and Vanuatu. (Unpublished doctoral thesis), University of Newcastle, Australia

Budiman, B. A., Sambegoro, P. L., Rahardian, S., Ilhamsyah, R., Firmansyah, R., Juangsa, F. B., & Aziz, M. (2020). Prediction of the remaining service lifetime of inflatable rubber dam with deep hole damage. *Indonesian Journal of Science and Technology*, *5*(3), 366-381.

Chu, C. R., Tran, T. T. T., & Wu, T. R. (2021). Numerical Analysis of Free-Surface Flows over Rubber Dams. *Water*, *13*(9), 1271.

Cochran, W. G. (1977). Sampling techniques (3rd ed.). New York: John Wily and Sons

Dong, S., Liu, B., Liu, H., Wang, S., & Wang, L. (2014). Impacts of groundwater recharge from rubber dams on the hydrogeological environment in Luoyang Basin, China. *The Scientific World Journal*, *2014*.

Gebhardt, M. (2010). On the causes of vibrations and the effects of countermeasures at water-filled inflatable dams. In *1st European Division Congress of the International Association of Hydraulic Engineering & Research (IAHR), Edinburg, UK* (pp. 1-6).

Ghorbani, M. K., & Hamidifar, H. (2023). Strategic planning of rubber dams by the SWOT and SWOT-AHP methods in Iran. *International Journal of Hydrology Science and Technology*, *15*(2), 112-122.

Ghorbani, M. K., Hamidifar, H., Skoulikaris, C., & Nones, M. (2022). Concept-Based Integration of Project Management and Strategic Management of Rubber Dam Projects Using the SWOT–AHP Method. *Sustainability*, *14*(5), 2541.

Guo, W., Zeng, W., Gao, X., & Ren, Y. (2023). Analysis of air-inflated rubber dam for flood-fighting at the subway entrance. *Journal of Flood Risk Management*, *16*(1), e12872.

Haiyan, D., Shisong, Q., & Qiang, H. (2015). Semi-quantitative Evaluation of Urban Landscape Water in Shandong Province of China. In *2015 AASRI International Conference on Circuits and Systems (CAS 2015)* (pp. 99-101). Atlantis Press.

Hasan, M. S., & Kabir, M. I. (2014). Feasibility of Natore Rubber Dam on Mahanonda river in Bangladesh and its performance on irrigation. *American Journal of Engineering Research*, *3*(1), 27-34.

Heidarnejad, M. (2017). Finding rubber dam installation site on the Karoon River, between Molasani and Ahvaz (Iran). *Journal of Water Science & Environment Technologies*, *2*(1).

Hu, Z., Guo, K., Yang, Y., & Zhang, M. (2023). Field survey and analysis of water flux and salinity gradients considering the effects of sea ice coverage and rubber dam: a case study of the Liao River Estuary, China. *Frontiers in Marine Science*, *10*, 1154150.

Jain, A. (2017), "*Rubber Dam- An Introduction*", Third National Dam Safety Conference, pp-336-346. Compendium of Technical Papers, India.

Jakeman, A. J., Barreteau, O., Hunt, R. J., Rinaudo, J. D., & Ross, A. (2016). Erratum to: Integrated Groundwater Management. *Integrated Groundwater Management: Concepts, Approaches and Challenges*, E1-E1.

Jena, S. K., Kumar, A., Brahmanand, P. S., Mishra, A., Sahoo, N., & Patil, D. U. (2015). Design and development of rubber dams for watersheds in the climate change scenario. *Climate change Modelling, planning and policy for agriculture*, 93-98.

Jena, S.K., Brahmanand, P.S., Mohanty, S., Sethi, R.R., and Ambast, S.K. (2018), "ICAR Flexi Check Dam (Rubber Dam) for Watersheds", ICAR-IIWM, Bhubaneswar.

Karmakar, S. (2019). Patterns of climate change and its impacts in northwestern Bangladesh. *J. Eng. Sci*, *10*, 33-48.

Karmakar, K. (2012, Jun 20), Rubber dam inflates hope in Dinajpur, The Daily Star. Bangladesh. https:// www.thedailystar.net/infrastruture/2012/Jun/20/ Rubber-Dam-Inflates-Hope-in-Dinajpur

Khan, M. S., Reza, M. E., & Rahman, M. M. (2004). Rubber Dams in Bangladesh Harness Surface Water for Farmers to Irrigate at Lesser Cost. In *Critical Transitions in Water and Environmental Resources Management* (pp. 1-10).

Khongsatjaviwat, D., & Routray, J. K. (2015). Assessment of capacities of TAOs and CBOs for local development in Thailand. In Dutt, A. K., Noble, A. G., Costa, F. J., Thakur, S. K., Thakur, R., & Sharma H. S. (Eds.), *Spatial Diversity and Dynamics in Resources and Urban Development: Volume 1: Regional Resources* (pp. 501–527). Dordrecht: Springer.

Kirby, M., Ahmad, M. D., Poulton, P., Zhu, Z., Lee, G., & Mainuddin, M. (2013). Review of water, crop production, and system modeling approaches for food security studies in the Eastern Gangetic Plains.

Kish, L. (1965). *Survey sampling*. New York: John Wiley & Sons

Kolte, D., Gangurde, P., Thakare, H., Shrivastav, N., and Mahajan, K. (2017). "Rubber Dam*", International Journal of Advance Research in Science and Engineering*, 6(3).

Laxman, P.G.M., and Shirsath, N.M. (2021), "*Techno feasibility analysis and design of inflatable rubber dam*", Journal of Emerging Technologies and Innovative Research, 8(5).

LGED. (1994). *Feasibility of rubber dams in Bangladesh*. Institute of Water Conservancy and Hydroelectric Power Research, China and Technical Design Unit, ISP, ESP, Local Government Engineering Department: Dhaka, Bangladesh

Markus, M. R., Thompson, C. A., & Ulukaya, M. (1996). Artificial recharge using inflatable rubber dams. In *North American Water and Environment Congress & Destructive Water* (pp. 736-741). ASCE.

Matkar, R. (2018), *"Rubber Dam: Design and Construction Aspect for Pune"*, Journal of Advances and Scholarly Researches in Allied Education, 15(2), pp. 242-250.

Michael, H. A., & Voss, C. I. (2009). Estimation of regional-scale groundwater flow properties in the Bengal Basin of India and Bangladesh. *Hydrogeol. J*, *17*(6), 1329-1346.

Molden, D. J., & Gates, T. K. (1990). Performance measures for evaluation of irrigation-water-delivery systems. *Journal of irrigation and drainage engineering*, *116*(6), 804-823.

Mojid, M. A., Aktar, S., & Mainuddin, M. (2021). Rainfall-induced recharge-dynamics of heavily exploited aquifers–a case study in the North-West region of Bangladesh. *Groundwater for Sustainable Development*, *15*, 100665.

Nooriafshar, M., Williams, R., & Maraseni, T. (2004). The use of virtual reality in education. Paper presented at the American Society of Business and Behavioural Sciences, 2004 Seventh Annual International Conference, Cairns, Australia.

Pakzad, P., Osmond, P., & Corkery, L. (2016). *Developing key sustainability indicators for assessing green infrastructure performance.* Paper presented at the International High-Performance Built Environment Conference - A Sustainable Built Environment Conference, Sydney, 17–18 December 2016, Series (SBE16).

Pal, I., & Ghosh, T. (2017). *Natural hazards management in Asia*. New Delhi: Sage

Parish, Y. (2016). Evaluating the design, construction, and use of rubber dams. *International journal of advanced biotechnology and research*, *7*(1), 159-166.

Paul, S., & Hasan, K. (2021). The impact of the proposed rubber dam facilitated surface water irrigation on adjacent groundwater at Chapai Nawabganj district, Bangladesh. *Applied Water Science*, *11*, 1-15.

Pender, J., Berhanu, G. 2002. *Impacts of policies and technologies in dry land agriculture: Evidence from northern Ethiopia*. Paper presented at the symposium on challenges and strategies of dry land agriculture into the new millennium. Annual meeting of the American Society of Agronomy, the Crop Science.

Pour Ahmad, A., Hussein, S. A., Sejoudi, M., & Ghorbani, R. (2022). Investigation of the impact of rubber dams on the development of water resources of urban areas in Gilan Province, Iran. *Central Asian Journal of Environmental Science and Technology Innovation*, *3*(4), 120-127.

Rahman, M. A., & Hasan, M. M. (2016). Performance evaluation of Buraghat rubber dam project in irrigation development at Haluaghat in Mymensingh. *Tech. J. River Res. Inst*, *13*(1), 26-36.

Rane, A. V., Thakur, S., & Thakur, R. (2019). Rubber dam—An introduction. In *Hydraulic Rubber Dam* (pp. 1-9). William Andrew Publishing.

Roehman, F., Wahyudi, S., & Ni'am, M. (2018). The design of water-filled rubber dam as an efficient innovation in preventing tidal flood (Rob). In *The 1st International Conference on Computer Science and Engineering Technology Universitas Muria Kudus*.

Roy, D.K.C. (2020, February 4). History of Irrigation Development in Bangladesh. Daily Sun, History of Irrigation Development in Bangladesh | Online Version (daily-sun.com)

Saleh, A. F. M., & Mondal, M. S. (2001). Performance evaluation of rubber dam projects of Bangladesh in irrigation development. *Irrigation and Drainage: The Journal of the International Commission on Irrigation and Drainage*, *50*(3), 237-248.

Saleh, A. J. M. (2008). Impacts of the Kawraid river rubber dam project on agricultural performance and poverty.

Sarker, K. K., Wang, X. Y., Islam, N., Xu, C. L., & Qiao, X. D. (2011). Performance Evaluation of the Rubber Dam project for irrigation development. *Scientific research and Essay*, *6*(22), 4700-4707.

Shirazy, B. J., Islam, A. B. M. J., Dewan, M. M. R., & Shahidullah, S. M. (2017). Crops and cropping systems in Dinajpur region. *Bangladesh Rice J*, *21*(2), 143-156.

Shivhare, K.V., Kathuria, S., and Sharma, A. (2016). Prospects of Rubber Dam in Indian Scenario. International Journal of Engineering Science and Research.

Singha, A., Kader, A. M., Akter, T., Gope, L. H., Jiku, S. A. M., Rahaman, A. M., and Ali, M. (2019), "Performance evaluation of the rubber dam for improving socio-economic status of rural Bangladesh", International Journal of Biosciences (IJB), 14(5), (pp.527-533).

Spriha, S. V. R. K. G., & Shukla, P. A. M. S. Sampling Typology and Techniques.

Sunny B.S. (2022, January 16), A dam that has changed lifescape for farmers in Dinajpur, The Business Standard. Bangladesh. https://www.tbsnews.net/ bangladesh/infrastructure/dam- has-changed-lifescape-farmers-dinajpur-358030

Tagwi, D. (2015). *Inflatable weir hydraulics* (Doctoral dissertation, Stellenbosch: Stellenbosch University).

Tam, P. W. (1998). Application of inflatable dam technology–problems and countermeasures. *Canadian Journal of Civil Engineering*, *25*(2), 383-388

Tam, P. W. M. (1997). Use of rubber dams for flood mitigation in Hong Kong. *Journal of irrigation and drainage engineering*, *123*(2), 73-78.

The Republic of Indonesia. (2005). The study on capacity development for Jeneberang River Basin Management (Volume-I), JICA.

Topalian, G., and Barron, G. (2017). "Inflatable rubber dam for hydropower applications", *The International Journal on Hydropower and Dams*, 24(3).

Trinugroho, M. W., Bhatta, B., & Babur, M. (2020). The seawater intrusion under dam failure in the Cimanuk River Estuary, Indonesia. *Regional Studies in Marine Science*, *36*, 101267.

Ul Islam, S., & Kumar, A. (2016). Inflatable dams for shp projects. *Renewable and Sustainable Energy Reviews*, *57*, 945-952.

Yadav, V., Mehta, D., Waikhom, S., & Gec, S. S. (2015). Suitability of rubber dam as a river water management tool. In *Proceedings National Conference on Recent Research in Engineering and Technology. Dr. Jivraj Mehta Institute of Technology* (pp. 16-22).

Yamane, T. (1967). *Statistics: An introductory analysis*. New York: Harper & Row

Zhang, Q., & Diao, Y. (2011). Cascade rubber dams fall discharge calculation and analysis. *Canadian Journal of Civil Engineering*, *38*(8), 957-962.

Zhang, X. Q., Tam, P. W., & Zheng, W. (2002). Construction, operation, and maintenance of rubber dams. *Canadian Journal of Civil Engineering*, *29*(3), 409-420.

Appendix

Field Survey Photographs, 2023

Source: Field Survey, 2023

Photo 11: Key Informant Interviews

Source: Field Survey, 2023

Source: Field Survey, 2023 Photo 12 : FGDs and Fishing, Farming Lands

নমুনা নং
গ্রাম

ভূগোল ও পরিবেশ বিভাগ
ঢাকা বিশ্ববিদ্যালয়
এমএসসি (মাস্টার্স)- ২০২০-২১, ; কোর্স নং-

(দিনাজপুর জেলার কৃষি ও আর্থ-সামাজিক অবস্থার উপর মোহনপুর রাবার ড্যাম প্রজেক্টের প্রভাব মূল্যায়নের জরিপ)

অংশ - ক: সাক্ষাৎদাতা সম্পর্কিত তথ্য

নিচের প্রশ্নগুলো ভাল করে পড়ুন এবং আপনার উত্তর অনুযায়ী 'হ্যাঁ' বা 'না' ঘরে টিক (√) চিহ্ন দিয়ে উত্তর দিন। প্রয়োজনীয় ক্ষেত্রে প্রশ্নের নিচের খালি জায়গায় লিখে আপনার উত্তর দিন।

১। উত্তরদাতার বয়স .....বছর

২। উত্তরদাতার লিঙ্গ পরিচয়ঃ (ক) পুরুষ (খ) মহিলা (গ) অন্যান্য

৩। উত্তরদাতার পেশা.....

৪। উত্তরদাতার পরিবারের ধরনঃ (ক) একক পরিবার (খ) যৌথ পরিবার (গ) একক পিতা/মাতা (ঘ) অন্যান্য

৫। পরিবারের সদস্যসংখ্যা.....
৬। উত্তরদাতার ধর্মঃ (ক) ইসলাম (খ) হিন্দু (গ) খ্রিস্টান (ঘ) বৌদ্ধ (ঙ) অন্যান্য

৮। উত্তরদাতার শিক্ষাগত যোগ্যতা? (ক) প্রাইমারী (খ) নিম্নমাধ্যমিক (গ) মাধ্যমিক (ঘ) উচ্চমাধ্যমিক (ঙ) অনার্স (চ) মাস্টার্স (ছ) অন্যান্য

৭। আপনারা এই এলাকায় কত বছর ধরে বসবাস করছেন.....বছর

অংশ – খ: সাক্ষাৎদাতার আর্থ-সামাজিক তথ্য

৯। উত্তরদাতার পেশার পরিবর্তন হয়েছে কিনাঃ হ্যাঁ | না
হ্যাঁ হলে.....

ড্যাম তৈরির আগে কি ছিলো	ড্যাম তৈরির পরে কি ছিলো

১০। উত্তরদাতার দৈনিক আয় কত……টাকা *পরিবারের অন্য সদস্যদের

আয়……টাকা

১১। রাবার ড্যাম প্রকল্প হওয়াতে আপনার বার্ষিক আয় পূর্বের চেয়ে বর্তমানে বৃদ্ধি পেয়েছি কি ? বৃদ্ধি পেলে আনুমানিক কত টাকা বৃদ্ধি পেয়েছে?

হ্যাঁ না

কি পরিমাণে বেড়েছে……

কিভাবে বেড়েছে……

১২। রাবার ড্যাম প্রকল্প হওয়াতে এলাকাতে জনগণের দারিদ্রতা হ্রাস পেয়েছে কি?

হ্যাঁ না

পেলে কিভাবে তা আপনি বুঝতে পারছেন?.....
……
……

১৩। রাবার ড্যাম প্রকল্প হওয়াতে পরিবারের সদস্যদের মধ্যে কারো কর্মসংস্থান হয়েছে কি? কর্মসংস্থান বৃদ্ধি পেলে বর্তমানে তারা কি ধরনের কাজে নিয়োজিত আছে?

হ্যাঁ না

……
……

১4। ড্যাম তৈরির ফলে আপনারা কি লাভবান হয়েছেন?

হ্যাঁ না

হ্যাঁ হলে, কিভাবে লাভবান হয়েছেন?.....
……
……
……..

১৩। ড্যাম তৈরির ফলে ভুমি ব্যবহারে কোনো পরিবর্তন এসেছে কিনা?

হ্যাঁ না

উত্তর হ্যাঁ হলে,
কিভাবে পরিবর্তন এসেছে?.....
……

১৪। কোনো সঞ্চয় করেন কি? হ্যাঁ না

উত্তর হ্যাঁ হলে, বাৎসরিক সঞ্চয়ের পরিমাণ কত?.....টাকা

কোথায় সঞ্চয় করেন?.....

১৫। আপনি কি কোনো ঋণ গ্রহন করেছেন? হ্যাঁ না

উত্তর হ্যাঁ হলে, কোথা থেকে নিয়েছেন·····
কত টাকা নিয়েছিলেন·····টাকা

কেন নিয়েছিলেন·····

১৬। স্থায়ীভাবে শহরে যাওয়ার প্রবণতা আছে? হ্যাঁ না

উত্তর হ্যাঁ হলে, কোথায় যায়? (ক) দিনাজপুর শহরে (খ) রংপুর শহরে (গ) ঢাকায় (ঘ) অন্যান্য জায়গায়

১৭। রাবার ড্যামের ফলে কি কেউ স্থায়ীভাবে উচ্ছেদ হয়েছে? হ্যাঁ না

উত্তর হ্যাঁ হলে, কতজন উচ্ছেদ হয়েছে?.....
.....

১৮। রাবার ড্যামের কারণে অন্য এলাকা থেকে এই এলাকায় চলে আসার প্রবণতা আছে কিনা?

হ্যাঁ না

উত্তর হ্যাঁ হলে, কেন অন্য এলাকা থেকে এই এলাকায় চলে আসছে বলে আপনি মনে করেন?.....
.....
.....

১৯। রাবার ড্যাম'কে কেন্দ্র করে কোনো রাজনৈতিক প্রভাব আছে কিনা? হ্যাঁ না

উত্তর হ্যাঁ হলে, কি রকম রাজনৈতিক প্রভাব?.....
.....

২০। রাবার ড্যাম প্রকল্প হওয়াতে যোগাযোগ ব্যবস্থা উন্নত হয়েছে কি? উন্নতি হয়ে থাকলে কি ধরণের উন্নতি হয়েছে বলে আপনি মনে করেন?

হ্যাঁ | না

……
……

২১। রাবার ড্যাম প্রকল্প হওয়াতে পরিবেশের উপর কোনো প্রভাব পরেছে কি? পরে থাকলে কোন কোন ক্ষেত্রে প্রভাব পরেছে বলে আপনি মনে করেন?

হ্যাঁ | না

……
……

২২। রাবার ড্যাম তৈরির প্রভাব সম্পর্কে সামগ্রিকভাবে নিম্নোক্ত বিষয়ে আপনার মতামত দিন:
(দৃঢ়ভাবে অসম্মত -১, অসম্মত -২, নিরপেক্ষ -৩, সম্মত -৪, দৃঢ়ভাবে সম্মত – ৫)

(√ চিহ্ন দিন)

বিবৃতি	দৃঢ়ভাবে অসম্মত	অসম্মত	নিরপেক্ষ	সম্মত	দৃঢ়ভাবে সম্মত
আপনার আয় বৃদ্ধি পেয়েছে					
কৃষিকাজে খরচ কমেছে					
কৃষিতে ফলন বেড়েছে					
বহির্গমনের প্রবণতা কমেছে					
অন্তর্গমনের প্রবণতা বেড়েছে					
ড্যামকে কেন্দ্র করে রাস্তাঘাটের উন্নয়ন হয়েছে					
মৎস্যজীবী ও কৃষকদের পেশাগত সুবিধা হয়েছে					
স্থানীয় রাজনৈতিক নেতাদের প্রভাব বেড়েছে					
সামগ্রিকভাবে জীবনযাত্রার মান বৃদ্ধি পেয়েছে					
কর্মসংস্থানের সুযোগ বৃদ্ধি পেয়েছে					
দারিদ্রতা হ্রাস পেয়েছে					
পরিবেশের উপর প্রভাব ফেলছে					
গ্রীষ্মকালে পানি সংকট কমেছে					

অংশ – গ: কৃষি সম্পর্কিত তথ্য

২৩। আপনার মালিকানায় কোন কৃষি জমি আছে কিনা?

হ্যাঁ | না

যদি হ্যাঁ হয় মোট পরিমান কত?.....বিঘা/একর

২৪। রাবার ড্যাম প্রকল্প হওয়াতে আপনার আবাদি জমির পরিমান বৃদ্ধি পেয়েছি কি? যদি বৃদ্ধি পেয়ে থাকে তবে কি পরিমান পেয়েছে?

হ্যাঁ | না

……বিঘা/একর

২৫। আপনারা জমিতে একবছরে কয়বার ফসল উৎপাদন করতে পারেন?

১বার | ২বার | ৩বার

২৫। এই অঞ্চলে উৎপাদিত মৌসুমভেদে কৃষি পণ্য কি কি?

রবি শস্য (মধ্য অক্টোবর-মধ্য মার্চ)	খরিফ-১ (মধ্য মার্চ-মধ্য জুলাই)	খরিফ-২ (মধ্য জুলাই- মধ্য অক্টোবর)

২৬। রাবার ড্যাম প্রকল্প হওয়াতে আপনার পূর্বের চেয়ে বর্তমান ফসল উৎপাদনের পরিমান বৃদ্ধি পেয়েছে কি? যদি বৃদ্ধি পেয়ে থাকে তবে কি পরিমান বৃদ্ধি পেয়েছে?

হ্যাঁ | না

……মন বিঘা/একর প্রতি

২৭। রাবার ড্যাম প্রকল্প বাস্তবায়নের পূর্বে এবং পরে বিঘা প্রতি ফসল উৎপাদনের পরিমান (মণে) প্রকাশ করুন?

ফসলের নাম	বর্তমানের পরিমান (মণ)	পূর্বের পরিমান (মণ)
ধান		
গম		
ভূট্টা		
আলু		

টমেটো		

২৮। রাবার ড্যাম প্রকল্প বাস্তবায়নের পর আপনাদের চাষকৃত ফসলের কোনো পরিবর্তন হয়েছে কিনা?

হ্যাঁ না

উত্তর যদি হ্যাঁ হয়,

পূর্বে কি ফসল ছিলো	বর্তমানে কি ফসল

২৯। বর্তমানে এক মৌসুমে এক বিঘা/একর আবাদি জমিতে সেচ দিতে আপনাদের কত টাকা খরচ হয়?..... টাকা

৩০। বর্তমানে সেচের পানির উৎসগুলো কি কি?

ভূগর্ভস্থ পানি ড্যামে জমানো পানি বৃষ্টির পানি অন্যান্য উৎস

৩১। রাবার ড্যাম বাস্তবায়নের পর সেচের পানির উৎস কি পরিবর্তন হয়েছে?

হ্যাঁ না

হ্যাঁ হলে,

পূর্বে কি ছিলো	বর্তমানে কি

৩২। রাবার ড্যাম বাস্তবায়নের পর আপনাদের বিঘা/একর প্রতি সেচের খরচ কি কমেছে কিনা?

হ্যাঁ না

উত্তর হ্যাঁ হলে,

পূর্বে বিঘা/একর প্রতি কত ছিলো	বর্তমানে বিঘা/একর প্রতি কত

৩৩। ফসল উৎপাদনের জন্য আপনি কি জমিতে কোনো সার ব্যবহার করছেন?

হ্যাঁ	না

উত্তর হ্যাঁ হয়ে থাকলে, কি কি সার ব্যবহার করছেন?.....
……

৩৪। রাবার ড্যাম বাস্তবায়নের ফলে আবাদি জমিতে সার ব্যবহারের পরিমাণ কি কমেছে বলে আপনি মনে করেন?

হ্যাঁ	না

উত্তর হ্যাঁ হয়ে থাকলে, কেনো কমেছে বলে আপনার মন হয়……
……
……

৩৫। রাবার ড্যাম প্রকল্প হওয়াতে মাছ প্রাপ্তির পরিমান পূর্বের চেয়ে বৃদ্ধি পেয়েছে কি?

হ্যাঁ	না

উত্তর হ্যাঁ হলে, বৃদ্ধি পেলে আনুমানিক কি পরিমান বৃদ্ধি পেয়েছে?.....টাকা

৩৬। ড্যামের পানি সেচের কাজে ব্যবহারের জন্য কোনো টাকা দিতে হয়?

হ্যাঁ	না

উত্তর যদি হ্যাঁ হয়, তাহলে কি পরিমান টাকা দিতে হয়?.....টাকা

৩৭। রাবার ড্যামের উপকারিতা কোন কোনক্ষেত্রে বিশেষভাবে উল্লেখ্য বলে আপনি মনে করেন?

……
……
……

৩৮। নিম্মোক্ত তথ্যের ভিত্তিতে আপনার মতামত দিন।
(অত্যন্ত অসন্তুষ্ট -১, অসন্তুষ্ট -২, নিরপেক্ষ-৩, সন্তুষ্ট -৪, অত্যন্ত সন্তুষ্ট – ৫)

(√ চিহ্ন দিন)

বিবৃতি	অত্যন্ত অসন্তুষ্ট	অসন্তুষ্ট	নিরপেক্ষ	সন্তুষ্ট	অত্যন্ত সন্তুষ্ট
মোহনপুর রাবার ড্যামের সার্বিক ফলাফল					
আর্থ-সামাজিক উন্নয়নে মোহনপুর রাবার ড্যামের অবদান					

কৃষিরখাতকে লাভজনক করতে ড্যামের অবদান					
মৎস্যজীবীদের জীবিকা বৃদ্ধিতে ড্যামের ভুমিকা					
পানি ব্যবহারে ক্ষেত্রে ভূগর্ভস্থ পানির উপর চাপ কমাতে মোহনপুর ড্যামের ভূমিকা					

৩৯। নিম্মোক্ত তথ্যের ভিত্তিতে আপনার মতামত দিন।

(দৃঢ়ভাবে অসম্মত -১, অসম্মত -২, নিরপেক্ষ -৩, সম্মত -৪, দৃঢ়ভাবে সম্মত – ৫)

(√ চিহ্ন দিন)

বিবৃতি	দৃঢ়ভাবে অসম্মত	অসম্মত	নিরপেক্ষ	সম্মত	দৃঢ়ভাবে সম্মত
রাবার ড্যাম একটি লাভজনক স্থাপনা					
দেশের বিভিন্নস্থানে প্রয়োজনুসারে সরকারের উচিত আরো রাবার ড্যাম তৈরি করা					
নদীতে ড্যাম তৈরির ফলে নদীর স্বাভাবিক প্রবাহে বাধা সৃষ্টি করে যা পরিবেশের জন্য ক্ষতিকর					
উক্ত এলাকার মতো স্বল্প বৃষ্টিপাতের এলাকার ক্ষেত্রে ভূগর্ভস্থ পানির উপর চাপ কমাতে রাবার ড্যামের প্রয়োজনীয়তা রয়েছে					
রাবার ড্যাম পরিবেশগত ভাবে একটি স্থিতিস্থাপক/অভিযোজনকারী কাঠামো					
শুষ্ক মৌসুমে পানি সংকট থেকে বাঁচাতে মোহনপুর রাবার ড্যাম অত্যন্ত জরুরী ভূমিকা পালন করছে					

৪০। আপনি কি আর কিছু যুক্ত করতে চান?.....
……
……
……

ধন্যবাদ

Appendix - A

University of Dhaka

DECLARATION BY THE RESEARCHER

Date:

Title of the Thesis:……..……

……..……..……

Total Page:…….

Degree (MS/PhD/MPhil):……...……...……

Researcher:……...……..

Registration No:…… Session: ……..…...……

Department/Institute:…….……

Supervisor:……..……...

Co-Supervisor:……..…….

This is to report that the above thesis was scanned for similarity detection. The process and outcome are given below:

Software used:……..…….. Date: …….

Similarity Index:…….……

The complete report is submitted for review by the University.

We undertake the following:

a. The research work submitted is original.
b. The contents of the electronic version of the thesis/dissertation submitted herewith are the same as that submitted as the final hard copy of the thesis.
c. No sentence, table, paragraph or section has been copied verbatim from any other resource unless it is placed under quotation marks and duly referenced.
d. There is no fabrication of data or results which have been compiled.
e. There is no falsification by manipulating research materials, equipment or processes.

Signature of Researcher

Date:……..

Appendix -B

University of Dhaka

SUPERVISOR'S CERTIFICATE FOR EXCLUSION OF SELF-PUBLISHING WORK

Date:

Title of the Thesis:……..……

……...……...……

Total Page:…….

Degree (MS/PhD/MPhil):……...……...……

Researcher:……...……..

Registration No:……. Session: ……..…...……

Department/Institute:…….……

Supervisor:……..……...

Co-Supervisor:……..…….

The content of the thesis/dissertation mentioned above has been published in

1.

2.

3.

4.

This published work(s) has been included in the thesis/dissertation with appropriate citation of the original source and has not been submitted for any degree to any University/Institute. This published work(s) should be excluded from the plagiarism checking of the final dissertation.

Signature of Supervisor

Date:…….....