STATUS OF FISH PRODUCTION AND BIODIVERSITY IN KAWADIGHI *HAOR* OF MOULVIBAZAR DISTRICT

A Thesis
By

MD. ABU HENA MOSTOFA KAMAL
Examination Roll No.: 1302030103, Registration No.: 0757
Session: 2008-2009, Semester: July-December 2014

Submitted to the
Department of Aquaculture
Faculty of Fisheries
Sylhet Agricultural University, Sylhet-3100

In partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
in
Aquaculture

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December 2014

Dedicated to My Beloved Parents

ACKNOWLEDGEMENTS

At first, the author is remembering the Almighty Allah, the supreme authority of the universe, who empowers the author to complete the research work and the thesis for the Degree of Master of Science (M.S.) in Aquaculture.

The author finds a great pleasure in expressing his heartfelt indebtedness, sincere appreciation and profound regard to his supervisor ***Dr. Md. Tariqul Alam****, Associate professor, Department of Aquaculture, Sylhet Agricultural University, Sylhet, for his keen interest, scholastic guidance, valuable suggestions, generous help, affectionate feelings and constant encouragement from the beginning to the end of the research work and preparing this thesis.*

The author extends his profound gratitude and vast appreciation to his co-supervisor, Professor ***Dr. Md. Shahab Uddin****, Department of Aquaculture, Sylhet Agricultural University, Sylhet, for right guidelines, cordial inspiration and constructive criticism during the tenure of conducting this study. The Author also wishes to express his heartfelt indebtedness to Assistant Prof.* ***Dr. Muhammad Anamul Kabir*** *Sylhet Agricultural University, Sylhet, for his valuable advice to complete this research work. The Author specially acknowledges Assistant Professor* ***Md. Tawheed Hasan****, Lecturer* ***Aminur Rashid*** *and* ***Tawni Dey*** *for their continuous inspiration and co-operation at all stages of the research work.*

The author expresses his special thanks to ***Md. Abu Kawsar****,* ***Shisir Das****,* ***Md. Sharif Uddin*** *and* ***Abu Sufian*** *for their continuous inspiration, encouragement and generous help during the study period.*

The author expresses his deepest sense of gratitude to his beloved parents and family members for their moral support and constant blessing and also sacrificing their valuable time during this study.

The author also expresses heartfelt acknowledges to SAU Campus. The memories of university life will be bared in his heart throughout life. The author feels proud of his real friends. He is very grateful to his entire SAU class friends.

The author is very glad to express his deep sense of gratefulness to Bangladesh University Grant Commission for providing the project under which the research work was performed.

The Author
December 2014

ABSTRACT

A study was carried out to investigate the status fish production and biodiversity in Kawadighi *haor* of North-East region of Bangladesh from January to December 2014. The study was undertaken through direct catch assessment survey in three beels of the *haor* and direct interview with fisherman, general people and Upazila Fisheries Officer through questionnaire. A total of 87 fish and prawn species under 12 order and 25 family were found in the haor of which Cypriniformes got the top position having 37 species followed by Siluriformes (19), Perciformes (12), Channiformes (4), Synbranchiformes (4), Decapoda (3), Clupeiformes (2), Osteoglosiformes (2), Anguilliformes (1), Tetraodontiformes (1), Cyprinodontiformes (1) and Beloniformes (1). Four species among 12 critically endangered, 19 species among 25 endangered and 10 species among 14 vulnerable fish species were found in the studied *haor*. The hector-wise values of Shannon-Weaver diversity (H), Margalef's richness (d) and Pielou's (*J*) evenness indices were 2.98, 7.72 and 0.67 in Hawagulaia, 2.97, 7.52 and 0.67 in Patasingra and 2.61, 7.30 and 0.59 in Salkatua beel, respectively. Among 449 respondents 54.12% made positive comments on effect of aquaculture on fish production and biodiversity of the Kawadighi *haor* while 35.86% made negative comments and 10.02% made no comment on it. Moreover, average annual fish production of the *haor* was 704.09 kg/ha. SIS fish dominated the total production of the *haor*. It ranged between 70.57 and 51.8%. It was maximum in the non-stocked beel. Per hectare SIS production of non-stocked beel was lower than the fingerling stocked beel. Aquaculture may have positive impact on the fish production and biodiversity. The results indicate that Kawadighi *haor* is a very resourceful inland open waterbody in both biodiversity and production which may serve as a mother fishery and gene bank. So, conservation measures should be taken to protect the valuable resource.

CONTENTS

CHAPTER NO.	TITLE	PAGE NO.
	ACKNOWLEDGEMENTS	**i**
	ABSTRACT	**ii**
	CONTENTS	**iii**
	LIST OF TABLES	**iv**
	LIST OF FIGURES	**iv**
	LIST OF APPENDICES	**iv**
	LIST OF ABBREVIATIONS	**v**
CHAPTER ONE	**INTRODUCTION**	**1-3**
	1.1 Background of the study	1
	1.2 Biodiversity and its importance	1-2
	1.3 Importance of fisheries	2
	1.4 Aquaculture and its environmental effects	2
	1.5 Eutrophication	2
	1.6 Justification of the study	3
	1.7 Objectives of the study	3
CHAPTER TWO	**REVIEW OF LITERATURE**	**4-9**
CHAPTER THREE	**MATERIALS AND METHODS**	**10-15**
	3.1 Selection and description of the study site	10-11
	3.2 Flow diagram of methodology	12
	3.3 Period of the study	13
	3.4 Preparation of questionnaire	13
	3.5 Data collection	13
	3.6 Production estimation	14
	3.7 Biodiversity study	14
	3.8 Data processing and analysis	15
CHAPTER FOUR	**RESULTS AND DISCUSSION**	**16-24**
	4.1 Fish biodiversity	16-19
	4.2 Availability of fishes in Kawadighi *haor*	20
	4.3 Fish composition and production	20-22
	4.4 Species diversity	23
	4.5 Impact of aquaculture on fish biodiversity in Kawadighi *haor*	23-24
CHAPTER FIVE	**SUMMARY**	**25**
CHAPTER SIX	**CONCLUSION AND RECOMMENDATIONS**	**26**
	REFERENCES	**27-31**
	APPENDICES	**32-36**

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
Table 4.1	List of fish species recorded from study area during the experimental period	16-19
Table 4.2	Production (kg/ha) of different fish groups and prawn in the three beels	21
Table 4.3	Annual production of different fish groups and prawn in the *haor*	22
Table 4.4	Top ten fish species (by weight) of the studied beels	22
Table 4.5	Shannon-Weaver diversity, Margalef's richness and Pielou' evenness indices of fishes of three beels	23

LIST OF FIGURES

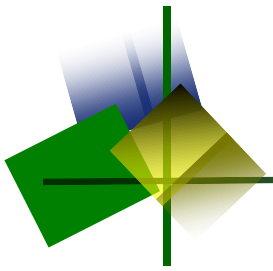
FIGURE NO.	TITLE	PAGE NO.
Fig. 3.1	Location of the study area	11
Fig. 3.2	Methodology of the present study	12
Fig. 3.3	Collection of data from the study area	14
Fig. 4.1	Fish species under different orders identified from Kawadighi *haor* during study period	20
Fig. 4.2	Composition of different fish groups and prawn in studied three beels	21
Fig. 4.3	Impact of aquaculture on fish biodiversity in Kawadighi *haor* (n=449)	24

LIST OF APPENDICES

APPENDIX NO.	TITLE	PAGE NO.
Appendix I	Catch Assessment Survey Form	32
Appendix II	Questionnaire for the impact study of aquaculture on fish biodiversity of the *Haor*	33-34
Appendix III	Questionnaire to UFO	35-36

LIST OF ABBREVIATIONS

BCAS	Bangladesh Centre For Advanced Studies
BHDB	Bangladesh *Haor* Development Board
CAS	Catch Assessment Survey
CPUE	Catch Per Unit Effort
DoF	Department of Fisheries
FES	Fishing Effort Survey
GDP	Gross Domestic Product
IUCN	International Union for Conservation of Nature
SIS	Small Indigenous Species
UFO	Upazila Fisheries Officer



CHAPTER ONE

INTRODUCTION

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INTRODUCTION

1.1 Background of the study

The word '*haor*' basically derived from the word '*saior*' which is the local pronunciation of *sagor* in *haor* region (Khan, l990). *Haor* are marshy wetland ecosystem in the north eastern part of Bangladesh which is physically a bowl or saucer shaped depression that look like inland seas during monsoon. During monsoon, the boundless deep water body of '*haor*` with strong wave looks like a sea. So, it is also called inland sea. During wet season, each of the settlements looks like an isolated island in a vast water body. The haor is inundated with monsoon rain and upstream water. The depth of inundation varies from 1 to l0 m. The villages are generally situated on the periphery of the *haor* (Talukder, 1993). During winter, *haor* contain little water and restricted to a small area and a large area is filled with paddy. A *haor,* in general, may be subdivided into three major areas which have similar characteristics in terms of morphology and hydrology. The *haor* basin of northeast region of Bangladesh encompasses the floodplains of the Meghna tributaries (greater Sylhet, Brahmanbaria, Kishoreganj and Netrokona) and is characterized by special type of inland water ecosystem with the presence of numerous *haor,* large deeply flooded depressions between the rivers. The basin bounded to the north by the hill ranges of Meghalaya to the south by the hills of Tripura and Mizoram and to the east by highlands of Monipur.

There are many *haor* in Bangladesh which is of different sizes. The Kawadighi *haor* is one of them, connected with Kushiara River. Its total area is 12295 ha occupying 63 beels. The Kawadighi *haor* is located around the Rajnagar sadar under Moulvibazar district connected to Kushiara River by Koradoyer khall. The Kawadighi *haor* site is a deeply flooded area during the monsoon season and some of the villages are exposed to wave action that causes erosion of homestead land.

1.2 Biodiversity and its importance

Biodiversity is the variety of living material in terms of genes, species and ecosystems within a given area (King, 1995). Biological diversity can be defined as the variety of life and its processes. Biodiversity is a fundamental part of the Earth's life support

system. It supports many basic natural services for humans, such as fresh water, fertile soil and clean air. Biodiversity helps pollinate our flowers and crops, clean up our waste and put food on the table. Without it we would not be able to survive. Throughout the world, fish form an indispensable part of the daily food intake. In Bangladesh, fish is not only treated as delicious food item but also an important component of farming system.

1.3 Importance of fisheries

Bangladesh, a tropical country having an area of 1, 47,570 sq. km, endowed with very considerable marine, estuarine and inland waters and rich and extensive fishery resources, with a wide variety of indigenous and exotic fish fauna (Rahman 1994). Fisheries sector play a very important role in the country's socio cultural and economic life; provide food, employment and foreign exchange (Rahman, 1994). This sector contributes about 4.37% to GDP, 23.37% to agriculture, 2.01% to the total foreign exchange and provides 60% of the animal protein consumed by the people in Bangladesh (DoF, 2014). Fish is an important traditional food item in the diet of the people. Fisheries sector provide full-time and part-time employment opportunity to about 17.1 million people in various dimensions such as fish harvesting, fish trading, processing, transporting, marketing, exporting and associated activates (DoF, 2014). The economic condition of Bangladesh is a rapidly developing in case of market-based economy.

1.4 Aquaculture and its environmental effects

Due to the decline of wild fisheries around the world, aquaculture has been able to grow rapidly. While many believe that aquaculture reduces pressure on fisheries. It means that aquaculture has positive effect on environment in case of production.

1.5 Eutrophication

An increasingly significant effect of intensive fish culture is eutrophication of the water surrounding rearing pens or the rivers receiving aquaculture effluent. Fish excretion and fecal wastes combine with nutrients released from the breakdown of excess feed to raise nutrient levels well above normal.

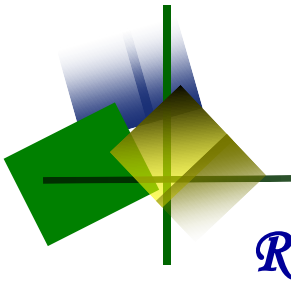
1.6 Justification of the study

The *haor* are enriched with various aquatic biodiversity along with 140 species of fish (Rahman, 2005). In open water, fish production is decreasing day by day except some fingerling stocked and co-managed water bodies. Some species are disappearing from individual water bodies although Hossain and Wahab (2012) found 289 freshwater fish species throughout the country (DoF, 2012). Still *haor* is richer than other part of the country. It has great importance in national economy, nutrition and rural livelihoods (Hasan, 2007). Still to date, *haor* area is rich with plenty of fish mainly indigenous species that has a very high demand to the consumers of country and abroad. However, it is reducing day by day. The government of Bangladesh has taken special initiatives for *haor* development through Bangladesh *Haor* Development Board (BHDB) especially for the development of fish and fisheries resources in this area. Now, degradation on biodiversity of aquatic environment is the prime concern to the environmentalists. Leaseholders of the beels of the *haor* stock carp fingerling as a part of aquaculture in their beels to increase fish production. But no sufficient information is available on the impacts of fingerling stocking on or the status of the fish production and biodiversity particularly for Kawadighi *haor*. For partial fulfillment of this lacking, attempt was taken to perform the study with a view to know the present status of fish production and species biodiversity, the impact of fingerling stocking on the biodiversity of fish, find out the status of endangered species in Kawadighi *haor* and the possible reasons for their decline.

1.7 Objectives of the study

With the above facts and views the study was performed to fulfill the following objectives:

- To assess the biodiversity and abundance of fish in the Kawadighi *haor*;
- To determine the impact of aquaculture on fish production and biodiversity;
- To find out the status of endangered fish species; and
- To know the possible reasons for degradation of fish biodiversity.



CHAPTER TWO

REVIEW OF LITERATURE

CHAPTER TWO

REVIEW OF LITERATURE

The present study is mainly concerned with the biodiversity of fish fauna and impact of aquaculture on biodiversity at Kawadighi *haor* of Raznagar upazilla in Moulvibazar district. The purpose of this review of literature is to describe the present status of knowledge on fisheries biodiversity of fish fauna and livelihood of fishermen of haor areas. So, the researcher attempts to review the available literature as related to the present study.

BCAS (1991) recorded the most common fish species such as punti, mola, chanda, chapila, tengra, carps, pabda, baim, taki and bujuri in the annual catches of the different beels viz; Kanglar *haor*, Karchanadi and Roail beel. The total annual catch composition of Roail beel was punti (13.69%), chapila (13.69%), batashi (12.54%), bujuri (8.53%), pabda (5.0%), mola (4.46%), tengra (2.3%), chanda (2.23%), bele (0.46%), carps (0.92%), taki (2.31%), chona (0.92%), shole (0.92%) and others (32.03%).

Rahman and Hasan (1992) observed that a total of 49 species of indigenous and 5 exotic fish species had been recorded from Kaptai Lake. Thirty one (31) indigenous and 3 exotic carp species were the commercially important species, forming the bulk of the catch.

Rahman *et al.* (1999) conducted a study in three floodplain beels within the Bangshi Dhaleswari floodplain in north-central Bangladesh during April-October 1996. Demonstrated a depth based floodplain fisheries assessment methodology. Ranking of concentration resulted in; prawn 44%, perch and gourami 17%, glassfish 12%, barb 11%, cyprinid 6%, snakehead 4%, gobies 3% and eel 3%. More species were found in deeper waters (depth>90 cm) than in shallower depth classes.

Shahjahan *et al.* (2001) recorded a total of 38 species of fish in the catches of different gears. Among the different types of nets, the highest number of species (25) was recorded in catches of ber jal, followed by jhaki jal (18) and relatively less number of species (7) was recorded in the catches of thela jal.

Saha and Hossain (2002) investigated the fishery of a perennial Saldu beel of Tangail, a total of 40 species of fish including four species of exotics. Three species of prawns and three species of turtles were listed. The average production of fish was recorded as 2429.47 kg/ha of which carp represented 34%, catfishes 26% and miscellaneous 40%.

Haroon *et al.* (2002) reported that a total of 92 species of` fish and prawn were recorded from the Sylhet-Mymensingh basin. In the Sylhet sub basin, *Puntius* spp. was the most dominant group comprising 19% of the total catch. Contributing of cat fishes (*Wallago* sp; *Mystus* spp; *Clupisoma* sp; *Clarias* sp. and *Heteropneustes fossilis*) were 18% and Gangetic major carps (*Labeo* spp; *Catla catla* and *Cirrhinus cirrhosus*) contributed to 16%, minnows were 13%, snakeheads were l1% of the total catch.

Hossain *et al.* (2003) reported that the species diversity and production had been decreased a lot in last few decades due to water habitat destruction, over exploitation and some other causes. In the river systems as much as 158 species were recorded but in floodplains 134 and 83 species were available with water current and without water current respectively.

Faroque (2006) stated that Barobela beel possessed a rich biodiversity of aquatic fauna having 43 species of fish, of which 29 were common, 5 endangered and 9 critically endangered. Twelve locally extinct species were also recorded. Among non-piscine biodiversity 4 species of prawns, 5 species of mollusks, 6 species of aquatic insects, 4 species of amphibians and 5 species of` reptiles were identified.

Hossain (2007) recorded forty-nine species of fish in the catch of different gears by the fishermen in Kolimar *haor*. Among these species, 12 species of catfishes, 7 species of carps, 5 species of perches, 4 species of snakeheads, 3 species of clupeids, 3 species of eel, 8 species of barbs and minnows and other 7 miscellaneous species were recorded. Among 6 different types of nets, the highest number of species were recorded in the catches of seine net (32) closely followed by cast net (27) and the lowest number of species were recorded in the catches of push net (11).

Saha (2007) estimated that a total of 77 freshwater finfish and shellfishes belonged to nine orders, 24 families and 53 genera were identified from three beels. Among total

number of species, 75 were finfish species (69 indigenous and 6 exotic species) and remaining two were freshwater prawn. Highest 72 fish and prawn species were recorded in Boro beel followed by 58 species in Gawha beel.

Hossain *et al.* (1999) undertook a study to investigate impacts of carp stocking on fish species diversity. The Shannon-Weaver diversity index was used to determine the diversity and evenness of fish caught. In one beel where stocking ended after two years, diversity (disregarding stocked fish) declined; in the beel where stocking took place for four years, diversity showed no trend. The species caught in most abundance were small resident species. Many species were not caught in all years of the study, indicating very low populations. A ranking of commoner and rarer species was made for each floodplain. The study did not show clear evidence of low diversity in stocked floodplains. But a longer term study is needed to compare stocked and non-stocked floodplain beels.

Halder *et al.* (1991) reported a total of 66 endogenous and 5 exotic species of fishes belonging to 49 genera available in Kaptai Lake.

Jhingran (1991) reviewed the species diversity of some important lakes and reservoirs of India. The classic work reported that 152 species of fish and 21 species of prawns from Chilka Lake and 65 species of fish from Pulicat Lake.

Talwar and Jhingran (1991) gave an account of inland fishes of India and its adjacent countries (Pakistan, Nepal, Myanmar, Sri Lanka and Bangladesh) which include 930 species of fishes.

Mortuza (1997) recorded 126 fish and 13 species of fisheries items from the Barnai (FCD) project area.

Nuruzzaman (1997) recorded 104 species of fish from Tanguar *hoar* in Sunamganj district.

Ramakrishniah and Das (1998) stated that the fish fauna of Markonahali reservoir is characterized by low species diversity. Only 28 species belonging to ten families have been recorded from the reservoir, out of which 23 are indigenous, four stocked and one exotic species. Family cyprinidae was represented by 15 species (including the

stocked ones) followed by channidae (3 species) and siluridae (2 species). Other families were represented by single species.

IUCN Bangladesh (2000) recorded a total of 266 inland and 442 marine fish species in Bangladesh among which 54 species of inland fish have come under different categories of threat in the country.

Rahman (2000) observed that thirty-three fish species were present in Rajdhala beel. Among them 10 species were stocked fishes and 23 species are non-stocked indigenous species. In the Padmai beel about 26 species of fish were seen during study period. Among them, six stocked fishes and 23 species are non-stocked indigenous species were recorded, non-stocked wild fish contributed bulk of the total harvest.

Sugunan and Bhattachariya (2000) reported that about 54 species belonging to 18 families were recorded from Dighali beel. The common species contributing to commercial landing belong to eight groups such as carps (Indian major carps like *Labeo bata* and *Cirrhinus reba*), Catfishes (*Sparata seenghala*, *S. aor* and *Wallago attu*), Murrels (*Channa* spp.), Featherbacks (*Notopterus chitala* and *N. notopterus*), Air breathing fishes (*Colisa* spp, *Clarias batrachus* and *Heteropneustes fossilis*), Hilsa (*Tenualosa ilisha*), prawns (*Macrobrachium* spp.) and miscellaneous fishes (*Puntius* spp, *Gudusia chapra, Rasbora* spp. and *Mystus* spp.)

IUCN Bangladesh (2003) recorded a total of 54 threatened indigenous fish species in the country including 14 vulnerable, 28 endangered and 12 critically endangered fish species.

Ali *et al.* (2004) studied on the availability of the fish species in the fish landing centers of Khulna district. The study recorded a total of 139 inland and marine water fish and crustacean species. Among the total 139 species, the number of' fin fish was 126 including 53 freshwater fish species. The study also found that 19 species are endangered including 7 catfish species (*Ompok pabda, Mystus aor, Rita rita, Euthropiichthys vacha, Wallago attu, Pangasius pangasius and Bagarius bagarius*).

Nishat *et al.* (2005) conducted a study in the Nali beel which identified a total of 79 fish species including 38 rare species. Over the last 2 decades, 4 species of fish have

become very rare in Nali, namely Boro chela (*Salmostoma bacila*), Phul chela (*Salmostoma phul*), Rani (*Botia lohachata*) and Meni (*Nandus nandus*).

Azadi (2007) recorded that 64 species of finfish under 13 orders, 5 species of shell fish, 1 species of turtle and 1 species of river dolphin (susuk) in Halda River.

Chakrabarti (2007) recorded a total of 72 aquatic animal species including 64 species fish, 3 species of prawn, 1 species of crab and 4 species of turtles in Someshari river of Netrokona district.

Hossain (2007) recorded different types of fishing gears broadly classified into three groups such as nets, traps and wounding gears operated by the fisherman in the Kolmar hoar. Among them a total of five types of nets, one type of trap and one type of wounding gear recorded during study period. He also recorded 49 species of fish in the catch of different gears by the fishermen.

Galib *et al.* (2008) recorded the indigenous fish species of Chalan beel are grouped under: 1 class, 12 orders, 26 families, 52 genera and 72 species. Nine exotic fish species are also recorded. A total of 28 threatened fish species are found in Chalan beel including vulnerable, 12 endangered, and 5 critically endangered species.

Ahshan (2008) recorded 105 fish species from Chalan beel. Among them 45 were threatened, 25 were endangered, 14 were vulnerable and 6 were critically endangered.

Sayeed (2010) reported that 106 species belong to 10 orders, 31 families and 71 genera among the threatened fishes (as described by IUCN, 2000) critically endangered (6), endangered (20), vulnerable (10) and data deficiency (18) were found from Chalan beel.

Hossain *et al.* (2003) reported that the species diversity and production had been decreased a lot in last few decades due to water habitat destruction, over exploitation and some other causes. In the river systems as much as 158 species were recorded but in floodplains 134 and 83 species were available with water current and without water current respectively.

Mostafa *et al.* (2009) reported that in 'Chalan beel' floodplains located in the Padma and Jamuna river basins serves the livelihoods of about 5 million people having the habitats of 114 different species of fish where 19 species earlier abundant are now

threatened. The annual fish production in 2005-06 from the floodplain was 12,217 tons which was half in amount than the production observed in 1982.

IUCN (2008) concluded that the total open water fish production of Sunamganj in one year was 45,173 MT and the estimated fish production from Tanguar *haor* was about 6,500 tons. The proportion of Tanguar *haor's* output compared to the output of Sunamganj district was 14% and compared to the whole of Bangladesh, it was 0.67%. The wetland served not only as a collection of fishing grounds, but also as a safe haven for migratory birds and as a hotbed of thriving biodiversity.

CHAPTER THREE

MATERIALS AND METHODS

CHAPTER THREE

MATERIALS AND METHODS

3.1 Selection and description of the study site

Before starting research a sound work plan was prepared for the whole research. Then the research topic was fine tuned with the consultation of supervisor and finally Kawadighi *haor* was selected as the research area. Kawadighi *haor*, once a mother fishery located at the north-centre of Monu river project, a multipurpose (flood control, drainage and irrigation) project covering a gross area of 22,700 ha surrounded by Kushiyara river in the north, Monu river in south and west and the foot of Bhatera hills in the east (Saleh, 1996), lying between longitudes $91^0 40' - 91^0 00'$ and latitudes $24^0 55' - 24^0 40'$N, situated immediately north of Moulvibazar, about 175 km northeast of Dhaka and 80 km southeast of Sylhet (Paul, 1997) was selected for this study. Three beels Hawagulaia, Salkatua and Patasingra were selected as sampling sites of which Hawagulaia was non stocked (fingerling) and Salkatua and Parasingra were stocked (fingerling). The Kawadighi *haor* is surrounded by 22 villages under 4 union named Panchgaon, Fatepur, Uttarbhag and Munsurnagor. The total area of the *haor* is 12295 ha. Location of the study sites are shown in the map (Fig. 3.1).

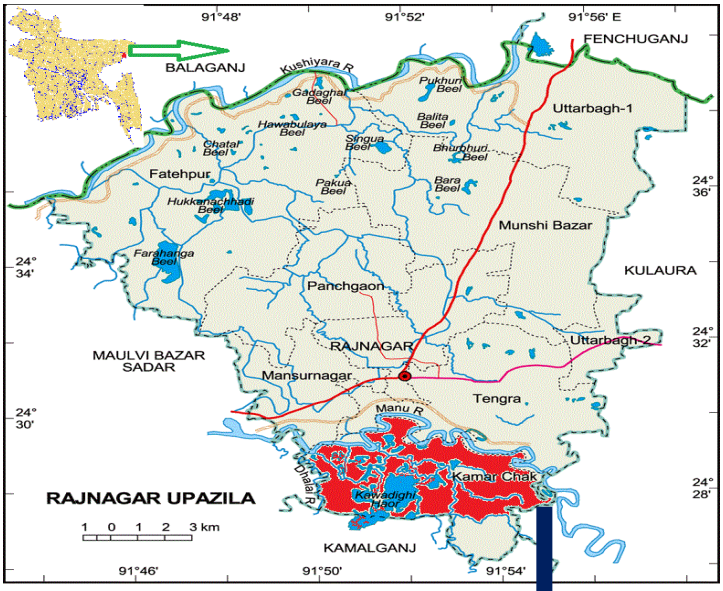


Fig. 3.1a: Location of the study area

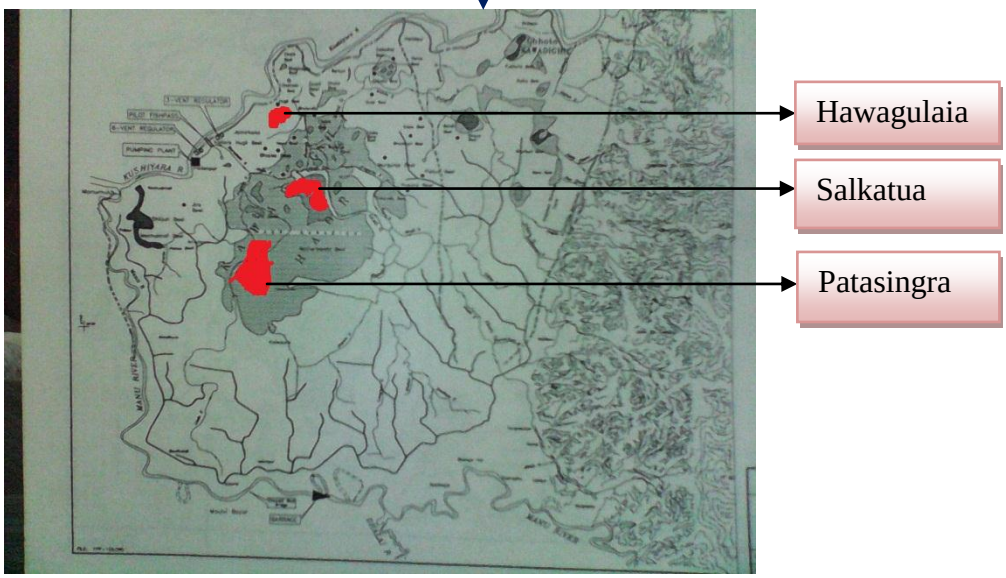


Fig. 3.1b: Kawadighi *haor* indicating sampling sites

3.2 Flow diagram of methodology

The present study has been undertaken and completed through the following steps (Fig: 3.2):

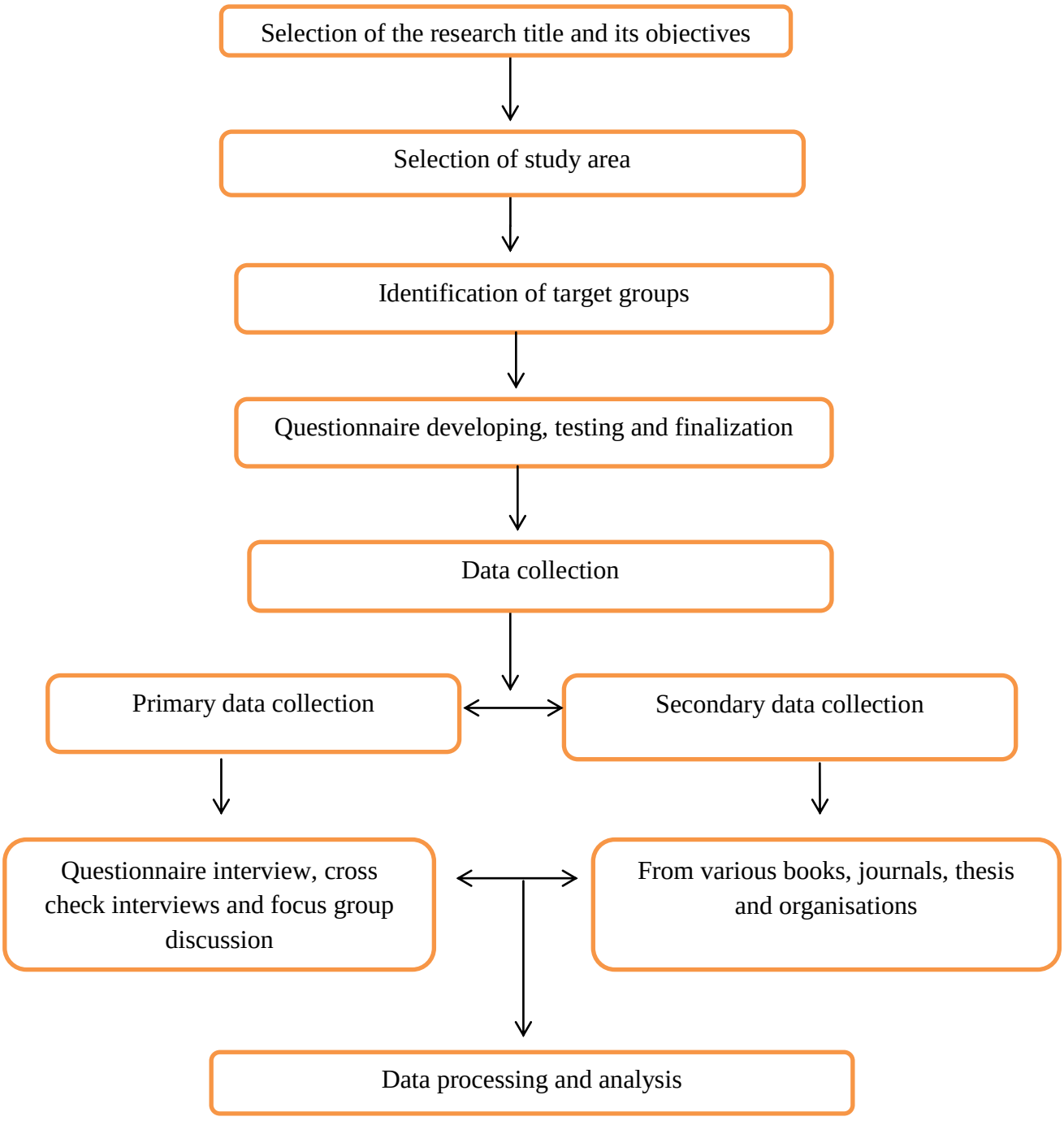


Fig. 3.2: Methodology of the present study

3.3 Study period

Data were collected by the researcher himself through personal interview with the fishers, farmers, general people and Upazila Fisheries Officer. The study was conducted for a period of l2 months from January to December 2014.

3.4 Preparation of questionnaire

In order to get a complete picture of fish biodiversity to fulfill the objectives of the study, a draft questionnaire was prepared. The draft questionnaire was pre-tested with few sample respondents. In pre-testing, attention was paid to incorporate any new information, which was not designed to be asked and filled in the draft questionnaire. The questionnaire was changed, modified and rearranged according to the experience gathered in pre-testing of questionnaire. The entire questionnaire was constructed in English.

3.5 Data collection

During collection of data, both primary and secondary sources were considered. Primary data were collected from fishermen by the researcher himself. The secondary information was collected from the Upazila fisheries officer.

Data were collected through direct interview. Each respondent was given a brief introduction about the purpose of the study during the interview. The questions were asked systematically in a very simple manner with explanations wherever necessary. Local customs and manner was always followed for collecting information and it was soon recorded. The recorded data were crosschecked subsequently. Some focus group discussions were also done with semi-structured and structured questionnaire. Besides, CAS (Catch assessment survey) and FES (Fishing Effort Survey i.e. the number of gears of different types operating in the site) were conducted bi-weekly in the same day in each site during fishing from January to December 2014. It was done sincerely so that all types of gear might be included. The catches were identified up to species and were recorded the number of specimen and weight species-wise as far as possible. If not possible, samples were marked, tagged, preserved and brought to the laboratory. Then it was identified and recorded according to Rahman (2005), Talwar and Jhingran (1991) and Shafi and Quddus (2001).

3.6 Production estimation

Total monthly catches by gear type were estimated from their average catch rates and average daily fishing effort. Species name, number and weight of fish of certain species in the daily catch and CPUE were recorded monthly and based on the monthly data, annual yield was calculated.

The total fish production of each sampling site was calculated from the modified formula of Hust and Bagley (1992) as:

Total catch from sampling sites for a specific gear = N × f × CPUE

Where, N is the number of fishing days per year,

F is the daily mean number of individual fishing unit and

CPUE is the mean daily catch per gear unit

For monthly production, N was counted as days per month. In this way, the total catch was estimated summing the amount of catch by different gears monthly or yearly.

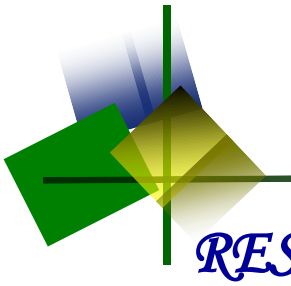
3.7 Biodiversity study

Species diversity was analyzed by the Shannon Weaver Index (H) (Shannon and Weaver, 1963), Species richness by Margalef index (d) (Margalef, 1968) and evenness by Pielou's index (J) (Pielou, 1966).

Fig. 3.3: Collection of data from the study area

3.8 Data processing and analysis

The collected data were summarized and processed for analysis. These data were verified to eliminate all possible errors and inconsistencies. The processed data were transferred to a master sheet from which classified tables were prepared revealing the tending of the study. For processing and analysis purpose MS Excel and MS word had been used, bar diagram, column diagram and pie diagram etc. had been used for data processing and analysis.



CHAPTER FOUR

RESULTS AND DISCUSSION

CHAPTER FOUR
RESULTS AND DISCUSSION

Kawadighi *haor* is a very important *haor* in the northeastern part of Bangladesh and riches with fish biodiversity.

4.1 Fish biodiversity

A total 87 species of fish and prawns belonged to 25 families under12 orders was recorded from the Kawadighi *haor* (Table 4.1). Out of 87 fish species, 77 indigenous, 7 exotic and remaining 3 were prawn species. Among the families, Cyprinidae dominated with 33 species followed by Bagridae with 7, Anabantidae with 5, Cobitidae, Channidae, Siluiridae and Schilbeidae each with 4 species, Mastacembelidae, Ambassidae and Palmonidae each having 3 species, Notopteridae and Clupeidae each with 2 species, Anguillidae, Synbranchidae, Tetraodontidae, Claridae, Heteropneustidae, Chacidae, Sisoridae, Mugilidae, Gobidae, Nandidae, Pristolepidae, Belonidae, Cyprinodontidae having 1 species each.

Table 4.1: List of fish species recorded from study area during the experimental period

Order	Family Name	Local Name	Species
Anguilliformes	Anguillidae	Bamosh	*Anguillla bengalensis* (Gray and Hardwicke)
Synbranchiformes	Synbranchidae	Kuchia	*Monopterus cuchia* (Hamilton)
Tetraodontiformes	Tetraodontidae	Potka	*Tetraodon cutcutia* (Hamilton)
Perciformes	Anabantidae	Kholisha	*Colisa fasciata* (Bloch and Schneider)
		Kholisa	*Trichogaster chuna* (Hamilton)
		Kholisha	*Colisa lalia* (Hamilton)
		Koi	*Anabas testudineus* (Bloch)
		Naptani	*Ctenops nobilis* (McClelland)
	Mugilidae	Khorsula	*Rhinomugil corsula* (Hamilton)
	Gobidae	Baila	*Glossogobius giuris* (Hamilton)
	Nandidae	Meni/ Bheda	*Nandus nandus* (Hamilton)
	Pristolepidae	Napit koi	*Badis badis* (Hamilton)

(Continued)

Order	Family Name	Local Name	Species
Perciformes	Ambassidae	Chanda	*Pseudumbassis ranga* (Hamilton)
		Chanda	*Chanda nama* (Hamilton)
		Chanda	*Pseudumbassis baculis* (Hamilton)
	Mastacembelidae	Tarabaim	*Macrognathus aculeatus* (Bloch)
		Baim	*Mastacembelus armatus* (Lecepedae)
		Chirkabaim	*Mastacembelus pancalus* (Hamilton)
Cyprinodontiformes	Cyprinodontidae	Kanpuna	*Aplocheilus panchax* (Hamilton)
Channiformes	Channidae	Shole	*Channa striatus* (Bloch)
		Taki	*Channa punctatus* (Bloch)
		Cheng	*Channa orientalis* (Schneider)
		Gozar	*Channa marulius* (Hamilton)
Cypriniformes	Cyprinidae	Chela	*Salmostoma phulo* (Hamilton)
		Chela	*Oxygaster gora* (Rahman)
		Chela	*Salmostoma bacaila* (Hamilton)
		Kashkhaira	*Chela laubuca* (Hamilton)
		Darkina	*Rasbora rasbora* (Hamilton)
		Darkina	*Esomus danricus* (Hamilton)
		Piali	*Aspidoparia morar* (Hamilton)
		Mola	*Amblypharyngodon mola* (Hamilton)
		Goinna	*Labeo gonius* (Hamilton)
		Bata	*Labeo bata* (Hamilton)
		Boga	*Labeo boga* (Hamilton)
		Kalibaush	*Labeo calbasu* (Hamilton)
		Mrigal	*Cirrhinus mrigela* (Bloch)
		Katla	*Catla catla* (Hamilton)
		Rui	*Labeo rohita* (Hamilton)
		Silver carp	*Hypophthalmichthys molitrix*
		Ketchki	*Corica soborna* (Hamilton)
		Lachu	*Cirrhinus reba* (Hamilton)
		Sarpunti	*Puntius sarana* (Hamilton)

(Continued)

Order	Family Name	Local Name	Species
		Thaipunti	*Puntius gonionotus* (Hamilton)
		Titpunti	*Puntius ticto* (Hamilton)
		Punti	*Puntius phutunio* (Hamilton)
		Punti	*Puntius chola* (Hamilton)
		Jatipunti	*Puntius sophore* (Hamilton)
		Carpio	*Cyprinus carpio*
		Carpio	*Cyprinus carpio var. spacularis*
		Carpio	*Cyprinus carpio var. communis*
		Bangna	*Labeo ariza* (Hamilton)
		Darkina	*Rasbora daniconius* (Hamilton)
		Chebli	*Danio devario* (Hamilton)
		Grass carp	*Ctenopharyngodon idella*
		Bighead carp	*Aristicthys nobilis*
		Dhela	*Osteobrama cotio* (Hamilton)
	Cobitidae	Gutum	*Lepidocephalus guntea* (Hamilton)
		Pahari gutum	*Somileptes gongota* (Hamilton)
		Rani	*Botia Dario* (Hamilton)
		Putul	*Botia lohachata* (Choudhuri)
Siluriformes	Clariidae	Magur	*Clarias batrachus* (Linnaeus)
	Siluridae	Boal	*Wallago attu* (Bloch)
		Boali pabda	*Ompok bimaculatus* (Bloch)
		Madhu pabda	*Ompok pabda* (Hamilton)
		Pabda	*Ompok pabo* (Hamilton)
	Heteropneustidae	Shingi	*Heteropneustes fossilis* (Bloch)
	Chacidae	Chaca/ kaua	*Chaca chaca* (Hamilton)
	Schilbeidae	Garua	*Clupisoma garua* (Hamilton)
		Bacha	*Eutropiichthys vacha* (Hamilton)
		Kazuli	*Ailia coila* (Hamilton)
		Batashi	*Pseudeutropius atherinoides* (Bloch)
	Bagridae	Air	*Sperata aor* (Hamilton)

(Continued)

Order	Family Name	Local Name	Species
		Tengra	*Mystus vittatus* (Bloch)
		Tengra	*Batasio tengra* (Hamilton)
		Guizza	*Sperata seenghala* (Sykes)
		Kabasi tengra	*Mystus cavasius* (Hamilton)
		Gulsha	*Mystus bleekeri* (Day)
		Buzuri tengra	*Mystus tengra* (Hamilton)
	Sisoridae	Jainzza	*Gangra viridescens* (Hamilton)
Osteoglossiformes	Notopteridae	Foli	*Notopterus notopterus* (Pallas)
		Chital	*Notopterus chitala* (Hamilton)
Clupeiformes	Clupeidae	Chapila	*Gudusia chapra* (Hamilton)
		Ilish	*Tenualosa ilisha* (Hamilton)
Beloniformes	Beloniidae	Kaikka	*Xenentodon cancila* (Hamilton)
Decapoda	Palaemonidae	Golda chingri	*Macrobrachium rosenbergii*
		Icha	*Macrobrachium spp.*
		kalo Icha	*Macrobrachium malcolmsonii*

Among the species, *Cyprinus carpio var. spacularis* could not found in Salkatua, *Cyprinus carpio var. spacularis*, *Tenualosa ilisha* (Hamilton), *Notopterus chitala* and *Aristichthys nobilis* in Hawagulaia, and *Aristichthys nobilis* in Patasingra beel. More or less same result was found by Alam *et al.* (2014). They recorded 85 species during 2007-08 in beel Kumari of Rajshahi District. Haroon *et al.* (2002) reported a total of 92 species of` fish and prawn from the Sylhet-Mymensingh basin. Nath *et al.* (2010) conducted a study in the Borulia *haor*, Nikli, Kishoregonj, who identified a total of 47 fish species which is much lower than the present study. Four critically endangered fish species viz. *Clupeisoma garua, Eutropiichthys vacha, Labeo boga,* and *Puntius sarana* and 19 endangered fish species viz. *Badis badis, Barasio tengra, Botia dario, Botia lohachata, Chaca chaca, Channa marulius, Chela labuca, Labeo bata, Labeo calbasu, Labeo gonius, Mastacembelus armatus, Mystus seenghala, Notopterus chitala, Ompok bimaculatus, Ompok pabda, Ompok pabo, Ctenops nobilis, Rasbora rasbora* and *Rohtee cotio* and 10 vulnerable fish species viz. *Anguilla bengalensis, Chanda nama, Pseudumbassis ranga, Channa orientalis, Cirrhinus reba, Sperata aor, Mystus cavasius, Nandus nandus, Notopterus notopterus and Puntius ticto* enlisted by IUCN (2000) were found in the studied *haor*.

4.2 Availability of fishes in Kawadighi *haor*

Kawadighi is one of the important *haor* in the northeastern part of Bangladesh and it serves as a nursery, breeding and feeding grounds of many freshwater fish species especially local fish. Waters were available for 10 months (May - February) in this *haor* and fishermen harvested fish mainly during June to February. A total of 87 fish species (including prawn) under 12 orders were recorded during the investigation period (Fig. 1). Among the orders Cypriniformes occupied the top rank having 37 species followed by Siluriformes (19), Perciformes (12), Channiformes (4), Synbranchiformes (4), Decapoda (3), Clupeiformes (2), Osteoglosiformes (2), Anguilliformes (1), Tetraodontiformes (1), Cyprinodontiformes (1) and Beloniformes (1) respectively.

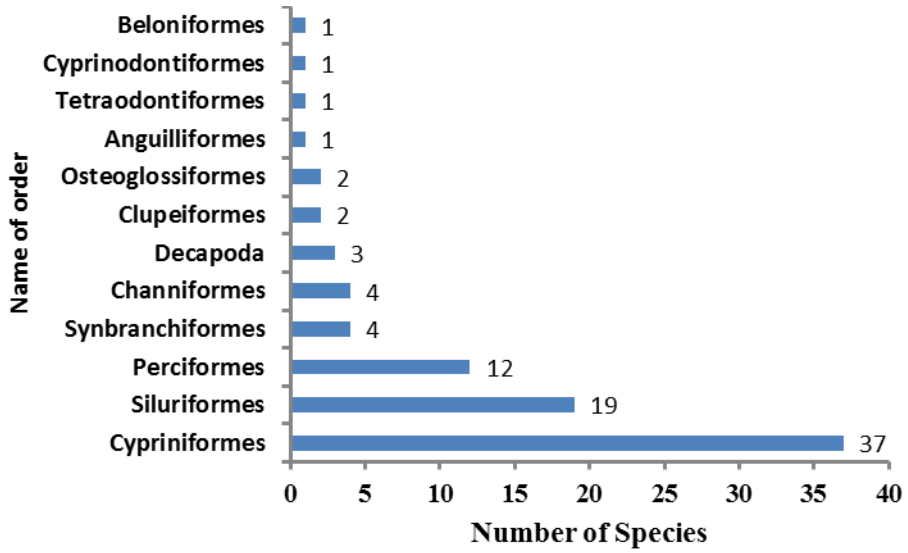


Fig. 4.1: Fish species under different orders identified from Kawadighi *haor* during study period

4.3 Fish composition and production

Fishes were divided into 4 groups, viz. SIS fish, large indigenous fish, large exotic fish and prawn. SIS fish occupied the highest position. It comprised 70.57, 51.8 and 63.43% for Hawagulaia, Patasingra and Salkatua beel respectively followed by Large exotic fish (13.72, 26.52 and 16.11% in Hawagulaia, Patasingra and Salkatua beel respectively) and Large indigenous fish (11.4, 26.52 and 16.11% in Hawagulaia, Patasingra and Salkatua beel respectively) (Fig 4.2). Prawn occupied the lowest position. The result indicates that SIS regulates the production of the *haor*; even in the

fingerling stocked beels SIS has a dominating capacity. Among the beels maximum SIS is in the non-stocked Hawagulaia beel indicating possible impact of fingerling stocking. But per hectare SIS production of Hawagulaia is lower than the fingerling stocked beels (Table 4.2). So, there may be other causes like shallow beel or smaller in size or ill management.

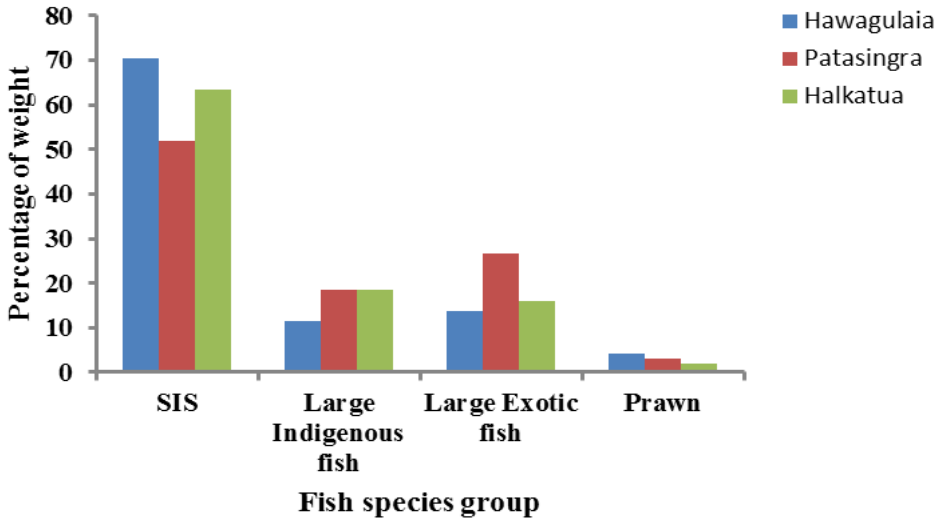


Fig. 4.2: Composition of different fish groups and prawn in studied three beels

Table 4.2: Production (kg/ha) of different fish groups and prawn in the three beels

Fish group	Hawagulaia	Patasingra	Salkatua
SIS	176.48	351.18	472.9
Large indigenous fish	28.5	151.87	137.1
Large exotic fish	34.3	220.92	104.1
Prawn	10.8	21.63	15.5
Total	250.08	745.6	729.6

Average annual SIS, Large indigenous fish, Large exotic fish and Prawn of the *haor* were 356.59, 139.84, 187.85, 19.81 and 704.09 kg/ha, respectively (Table 4.3). Total fish and prawn production of Kawadighi *haor* during the study year (2014) was 8656.789 mt (Table 4.3).

Table 4.3: Annual production of different fish groups and prawn in the *haor*

Fish group	Haor Total (mt)	Haor Average (kg/ha)
SIS	4384.262	356.59
Large indigenous fish	1719.305	139.84
Large exotic fish	2309.62	187.85
Prawn	243.6018	19.81
Total	8656.789	704.09

Table (4.4) also indicates that in non-stocked beel, three large fish occupied third, fourth and ninth position among top ten species, the rest were SIS. In Patasingra beel, five large fish and the rest five were SIS and in Salkatua beel, seven were SIS. The freshwater shark fish *Wallago attu* occupied the third position in the non-stocked beels and second position in the stocked beels indicating more or less successful recruitment of it.

Table 4.4: Top ten fish species (by weight) of the studied beels

SL No	Hawagulaia	Patasingra	Salkatua
1	*Puntius sophore*	*Cyprinus carpio*	*Puntius sophore*
2	*Puntius ticto*	*Wallago attu*	*Wallago attu*
3	*Wallago attu*	*Puntius sophore*	*Cyprinus carpio*
4	*Cyprinus carpio*	*Puntius ticto*	*Pseudumbassis ranga*
5	*Pseudumbassis ranga*	*Hypophthalmichthys molitrix*	*Mystus vittatus*
6	*Colisa fasciata*	*Pseudumbassis ranga*	*Puntius ticto*
7	*Mystus vittatus*	*Ctenopharyngodon idella*	*Gudusia chapra*
8	*Mystus cavasius*	*Cyprinus carpio var. spacularis*	*Hypophthalmichthys molitrix*
9	*Hypophthalmichthys molitrix*	*Colisa fasciata*	*Colisa fasciata*
10	*Nandus nandus*	*Mystus vittatus*	*Mystus cavasius*

4.4 Species diversity

Species diversity was studied with Shannon-Weaver diversity (H), Margalef's richness (d) and Pielou's evenness (*J*) indices. The hector-wise values of Shannon-Weaver diversity (H), Margalef's richness (d) and Pielou's (*J*) evenness indices are shown in Table 4.5. As shown in Table 4.5, *H, d* and *J* were 2.98, 7.72 and 0.67 in Hawagulaia, 2.97, 7.52 and 0.67 in Patasingra and 2.61, 7.30 and 0.59 in Salkatua beel, respectively.

Table 4.5: Shannon-Weaver diversity, Margalef's richness and Pielou's evenness indices of fishes of three beels

Study Area	Number of species (S)	Total Number of individuals (N)	lnN	Diversity, $H= -\sum PilnPi$	Richness, $d=\frac{S-1}{lnN}$	lnS	Evenness, $J=\frac{H}{lnS}$
Patasinghra	86	81958	11.31	2.97	7.52	4.45	0.67
Shalkatua	86	115376	11.65	2.61	7.30	4.45	0.59
Hawagulia	83	41011	10.62	2.98	7.72	4.42	0.67

Mondal *et al.* (2010) recorded H ranging 3.61- 3.95, *J* ranging 0.85- 0.94 and d ranging 0.08- 0.12 in floodplain lakes of India. SIS fishes were dominant in the present haor and d was higher and *J* was lower than Mondal *et al.* (2010). Hossain *et al.* (2012) recorded H 3.197625 (3.69- 2.83), *d* 6.3857 (6.863- 5.519) and *J* 0.4843 (0.558- 0.3555) which is more or less same to the present study.

4.5 Impact of aquaculture on fish production and biodiversity in Kawadighi *haor*

Two types of impact occurred such as positive impact and negative impact. When survey implemented, 449 respondents (lease holder, fisherman and general people) of this area gave their opinion about stocking. Some were positive and some were negative for stocking. Snapshot information is given in Figure 4.3.

Figure 4.3 reveals that there are mixed reaction among the stakeholders. Among the respondents 54.12% made positive comment where 35.86% made negative comment and 10.02% did not make any comment. But when asking the respondents who made negative comment if they have every freedom in catching fish or not, they told "no",

if so, is there any possibility of successful breeding of SIS for that reason, they told "yes, but they dewater the water bodies during winter". So, aquaculture may have positive impact on fish production and biodiversity in Kawadighi *haor*. Hossain *et al.* (2014) also recorded positive impact of floodplain aquaculture on ecology and fish biodiversity. However, all lease holders told that they were doing good both physically and biologically for fish production as well as biodiversity. Therefore, more research is necessary to find out if there if any other factors responsible behind it or not.

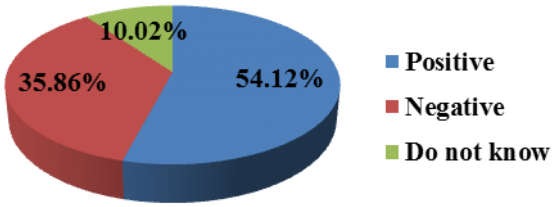
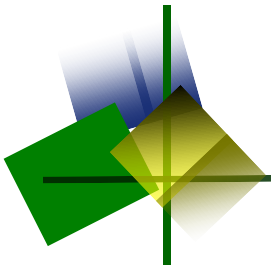


Fig. 4.3: Impact of aquaculture on fish production and biodiversity in Kawadighi *haor* (n=449)



CHAPTER FIVE

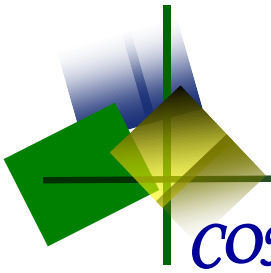
SUMMARY

CHAPTER FIVE

SUMMERY

The maiden study was carried out to determine the impact of aquaculture on fish diversity and production of the Kawadighi *haor* at Raznagar upazila under Moulvibazar district for a period of one year from January to December 2014. A total of 87 fish and prawn species under 12 order and 25 family were identified in the haor of which cypriniformes got the top position having 37 species followed by Siluriformes (19), Perciformes (12), Channiformes (4), Synbranchiformes (4), Decapoda (3), Clupeiformes (2), Osteoglosiformes (2), Anguilliformes (1), Tetraodontiformes (1), Cyprinodontiformes (1) and Beloniformes (1). Four species among 12 critically endangered 19 species among 28 endangered and 10 species among 14 vulnerable fish species of IUCN (2000) was found in the studied *haor*. Fish species of the study area were divided into four major groups *i.e.* SIS fish, large indigenous fish, large exotic fish and prawn. Among them, SIS fish occupied the highest position and comprised 70.57, 51.8 and 63.43% for Hawagulaia, Patasingra and Salkatua beel respectively followed by Large exotic fish (13.72, 26.52 and 16.11% in Hawagulaia, Patasingra and Salkatua beel, respectively) and Large indigenous fish (11.4, 26.52 and 16.11% in Hawagulaia, Patasingra and Salkatua beel respectively). Prawn occupied the lowest position. The result indicated that SIS regulates the production of the *haor*; even in the fingerling stocked beels SIS has a dominating capacity.

The annual fish and prawn production of Patasinghra, Shalkatua and Hawagulya beels were 745.6kg/ha, 729.6kg/ha and 250.08kg/ha respectively. Annual fish production of the haor was 704.09kg/ha. Among the beels, maximum SIS is in the non-stocked Hawagulaia beel indicating possible impact of fingerling stocking. The hector-wise values of Shannon-Weaver diversity (H), Margalef's richness (d) and Pielou's (*J*) evenness indices were 2.98, 7.72 and 0.67 in Hawagulaia, 2.97, 7.52 and 0.67 in Patasingra and 2.61, 7.30 and 0.59 in Salkatua beel respectively. Among 449 respondents 54.12% made positive comments on fish effect of aquaculture on fish production and biodiversity of the Kawadighi *haor* while 35.86% made negative comments and 10.02% made no comment on it. Aquaculture may have positive impact on the fish production and biodiversity.



CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

Conclusion

In this maiden study impact of aquaculture on fish production and biodiversity of Kawadighi *haor* was determined. Eighty seven different fish species belonging 25 families was identified. Four species among 12 critically endangered 19 species among 28 endangered and 10 species among 14 vulnerable fish species of IUCN (2000) was found in the studied haor, indicating very resourceful inland water open water body. Fish production of Hawagulaia, Patasinghra and Shalkatua beel were 250.08, 745.6 and 729.6kg/ha/yr. respectively. Average annual fish production of the haor was 704.09 kg/ha. Among 449 respondents 54.12% made positive comments on fish effect of aquaculture on fish production and biodiversity of the Kawadighi *haor* while 35.86% made negative comments and 10.02% made no comment on it.

Recommendations

- Prevention of water pollution, ensuring water flow, developing fisher's awareness, implementation of fish acts is essential.
- Overfishing should be stopped by any means.
- Declaration of perennial and seasonal (during breeding seasons) fish sanctuaries is essential to conserve the existing fish species for sustainable fish production.
- Policy makers should recognize the necessity for conservation of fish diversity and ensure multi-sectorial coordination for it.
- Further research is necessary in this area to cope out the *haor*, realize its biodiversity and production pattern and conserve its resources.
- Excavation of canals and beels is essential.
- A comprehensive study should be carried out on fishing effort for sustainable development of biodiversity.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APPENDICES

Appendix I: Catch Assessment Survey Form

Section I: Identification of the Fishermen

1 Farmer's Name **:** ……..

Father's **:** ……..

Village **:** ……..

Upazila **:** ……..

District **:** …….....

Mobile No. **:** ……..

Occupation: Primary: **:** ……..
Secondary: ……..

Section II: Catch Assessment Survey

1 Amount of catch: : ……..Kg

Duration of Fishing: : …….hr

No. of fishing days in a week in this site : ……..days

Do you fish round the year? : ☐ Yes ☐ No

2. Name of the available Species:

Sl. No.	Name	Wt.(gm.)	No. of fish

Signature of the Respondent

Date:

Signature of the Enumerator

Date:

Appendix II: Questionnaire for the impact study of aquaculture on fish biodiversity of the *Haor*

Section I: Identification of the Respondent

1 Farmer's Name **:** …….

Father's **:** …….

Village **:** …….

Upazila **:** …….

District **:** …….....

Mobile No. **:** …….

Occupation **:** …….

Section II: Observation of the respondent

1 Do you know about the fingerling stocking by the lease holder? : ☐ Yes ☐ No

2 Do you know the species stocked by the lease holder? : ☐ Yes ☐ No

3 Is there any effect of fingerling stocking on fish production? : ☐ Yes ☐ No

If yes, what it is?

……...

4 Is there any effect of fingerling stocking on fish biodiversity? : ☐ Yes ☐ No

If yes, what it is?

……...

5. Which species are available?

Sl. No.	Name

6. What are the threats for fish in this *haor?*

- ……
- ……
- ……
- ……
- ……

7. How to mitigate these threats?

- ……
- ……
- ……
- ……
- ……

Signature of the Respondent

Date:

Signature of the Enumerator

Date:

Appendix III: Questionnaire to UFO

Section I: Identification of the UFO

1 Name **:** ……..

Designation **:** ……

Upazila **:** ……..

District **:** …….....

Mobile No. **:** ……..

Section II: Cross Checking Interview

1 Do you know about the fingerling stocking by the lease holder? : ☐ Yes ☐ No

2 Do you know the species stocked by the lease holder? : ☐ Yes ☐ No

3 Is there any effect of fingerling stocking on fish production? : ☐ Yes ☐ No

If yes, what it is?

……...

4 Is there any effect of fingerling stocking on fish biodiversity? : ☐ Yes ☐ No

If yes, what it is?

……...

5. Which species are available?

Sl. No.	Name

6. Is there any documented report on the fish production of the *haor*?

- …….

7. Is there any documented report on the fish species biodiversity of the *haor*?

- …….

8. What are the threats for fish in this *haor?*

- ……
- ……
- ……
- ……
- ……

9. How to mitigate these threats?

- ……
- ……
- ……
- ……
- ……

Signature of the Respondent

Date:

Signature of the Enumerator

Date: