Factors influencing the production of tiger shrimp (*Penaeus monodon*) in Bagherhat

A thesis submitted to the University of Dhaka, Bangladesh for the fulfillment of the degree of Doctor of Philosophy (Ph.D.)

Submitted by

Md. Mahashin

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Department of Zoology

University of Dhaka

Bangladesh

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Dedicated

To

My beloved parents

MRS. HOSNEARA BEGUM and Late **MD. ALAUDDIN SHEIKH**

Without their love and encouragement this research could never been completed.

CERTIFICATION

This is to certify that thesis entitled **"Factors influencing the production of tiger shrimp (*Penaeus monodon*) in Bagherhat"**submitted to the Department of Zoology, Faculty of Biological Science, University of Dhaka, Dhaka, Bangladesh, in fulfillment of the requirement for the degree of Doctor of Philosophy is a record of bonafide research work carried out by Md. Mahashin Registration No. 45, Session: 2008-09 & 163, Session: 2015-16 (Re) under my supervision and suggestions. I have read this dissertation and that in my opinion it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy. Experimental work described in the thesis has been carried out by the author in the field and Department of Zoology, Dhaka University. The work is original and to the best of our knowledge, no part of this work has been submitted before any other degree or diploma.

Professor Dr. Md. Niamul Naser

Research Supervisor
Department of Zoology
University of Dhaka
Bangladesh.

Declaration

I do hereby declare that the whole work submitted as a thesis entitled **"Factors influencing the production of tiger shrimp (*Penaeus monodon*) in Bagherhat"**in the Department of Zoology, Faculty of Biological Sciences, University of Dhaka, Dhaka, Bangladesh, for the degree of Doctor of Philosophy is the result of my own investigation. No part of this thesis has been presented before for any degree, diploma or any other similar title to any University.

Md. Mahashin

Registration No. 45/2008-09 &
163/2015-16 (Re)
Department of Zoology
University of Dhaka
Bangladesh.

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ABSTRACT

A study was conducted to identify the factors which influence the production of tiger shrimp (*Penaeus monodon*) from Fakirhat, Mongla and Rampal Upazila under Bagerhat district. Data were collected from shrimp farms from 2012-2014 of above mentioned regions. Three uniform sized (0.202 Hectare) farms of improved extensive culture system and one uniform sized (0.121 Hectare) farm of extensive culture system were selected for the in depth analysis of the issue. The aforesaid improved extensive farms have water exchange facility and other farms were stagnant water bodies. The experiment was done for two production cycles from February-2013 to December 2014. Previously practiced farms were selected for this experiment with close observation. Farm preparation, stocking density, feeding and other management were almost the same. During this experiment all parameters were monitored and collected regular basis. Now a days shrimp culture pattern has been changed especially in stocking system in comparison to its initial stage. Most of the farmers are practicing improved extensive culture system, they stock shrimp with giant fresh water prawn (*Macrobrachium rosenbergii*), Horina chingri (*Metapenaeus monoceros*), Chaka chingri (*Feneropenaeus indicus*) and some brackish water fin fishes. Bagda and Golda production is not satisfactory according to stocking number but this practice is very common in this area. Mortality normally happened when Bagda reach in a size of 80-90 pieces per Kg. Fin fishes are stocked to mitigate the loss and also to have additional production.

After this experiment it was observed that production of tiger shrimp (*Penaeus monodon*) depends on various factors like inadequate water exchange, salinity fluctuation, accessing polluted water, feeding, disease outbreak, water parameters, soil condition, water depth, culture techniques, variable stocking density & stocking patterns, lack of good quality post larvae, lack of knowledge, predation and many other social factors like income level, education level, poaching, rumor, etc.

The production of this shrimp farms can be improved by introducing better management practices viz. farm preparation, water exchange, maintaining water depth, quality PL stocking, optimizing PL density and proper feeding practices for the major farms of the study area.

The improvement of shrimp sector is vital. It can only be achieved from the proper guidance of shrimp culture techniques, improved inputs and supply chain, governmental support.

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LIST OF ABBREVIATIONS

ADV	Acoustic Doppler Velocimeter
BRAC	Bangladesh Rural Advancement Committee
BWDB	Bangladesh Water Development Board
cm	Centimeter
^{0}C	Degree Centigrade
DoF	Department of Fisheries
DU	Dhaka University
DO	Dissolved Oxygen
GoB	Government of Bangladesh
g%	Gram Percentage
h	Hour
IUCN	International Union for Conservation of Nature
L	Litre
m	Meter
mg/l	Milligram/ Litre
NGO	Non Government Organization
PPT	Parts Per Thousand
SD	Standard Deviation
SUFO	Senior Upazilla Fisheries Officer
UFO	Upazilla Fisheries Officer

Chapter 1. Introduction

1.1 Background

Bangladesh ranks as the world's fourth-largest producer of fish that come from inland waterbodies. Although shrimp farming for subsistence has long been a part of the nation's fisheries industry, proper shrimp culture practices were established in the early 1980s. In the past, shrimp farming dates back to the 1930s; yet, commercial shrimp farming only got underway internationally in the 1970s. According to the Environmental Justification Foundation (2003), Bangladesh's 720 km of coastline provides the ideal environment for shrimp production, from farming to business. Over the past few years, the development of salty water shrimp in Bangladesh's coastal areas has gradually boosted the country's economy. While the proportional shares of freshwater and marine catch were 23% and 47%, respectively, the production of shrimp via coastal aquaculture accounted for around 30% of the total shrimp produced annually. About 9,000 homesteads in Bangladesh are supported by the 1% of shrimp produced using aquaculture techniques (Islam, 2010).

Shrimp farming communities' lower socioeconomic classes have frequently suffered as a result of the conflicting needs of people engaged in this industry and rice growers. On occasion, the growth of shrimp farming has resulted in the degradation of agricultural land, which has a severe impact on the local population's quality of life. To ensure the industry's continued growth, these disagreements must be resolved. Shrimp farming is also threatened by the disease outbreak. Its dependence on gathering wild shrimp fry poses another concern to the sustainability of shrimp farming. Due to the low-cost and destructive methods used to supply shrimp farmers with seed inputs, this activity currently supports a large number of households and severely depletes wild stocks of shrimp and other aquatic species. But in addition to these, a host of other issues are seriously harming the sub-sector, particularly in Bangladesh's south. As a result, the long-term viability of shrimp production and the advancement of shrimp farming are in jeopardy. To preserve this wonderful area of commercial and social interests, steps should be taken to identify and lessen the restrictions.

In Bangladesh, the practice of raising shrimp or prawns is referred to as "gher" farming. Aquaculture and agriculture are merged in the practice of gher farming. The shrimp/prawn gher farming technique has a big impact on Bangladesh's economy and agriculture. It has also produced a wide range of local job opportunities, such as those for depot owners, ice factories, mud snail dealers, and prawn fingerling sellers. The working force in this industry is made up largely of men and women. With the advent of the Gher Revolution, improvements have been made to the fundamental elements of a person's standard of living, including food consumption, healthcare, education, housing, and clothes. It was formerly impossible for those in this sector to eat three meals a day. Additionally, they are able to pay for their kids' educations (Barmon, 2003).

There are two varieties of gher farming in Bangladesh: freshwater rice-prawn farming and brackish water-based shrimp farming. Prawn gher farming is relatively small in size and scale and requires fresh water, while shrimp gher farming is enormous in size and scale and requires saline water. Freshwater-based prawns are traditionally cultivated in the upper sections of Bagerhat, Khulna, and Satkhira districts, whereas brackish water-based shrimp are cultivated in coastal and peri-coastal regions. As of right now, Bangladesh produces shrimp and prawns using the following methods: (Barmon et al. 2007).

Traditional Shrimp Production- In Bangladesh, the old gher farming method is still used in the current shrimp cultivation. Here, little wooden sluice gates regulate the flow of saltwater into the enclosed regions. From February to April, these sluice gates are opened to let saltwater into the gher, which is then filled with post-larvae of sea-breeding shrimp and juveniles of several types of coastal finfish. In order for the shrimp to reach a size that can be

Figure 1.1: Traditional shrimp Gher farming in Bangladesh

harvested, these sluice gates are closed after April. Shrimps are typically harvested in four to five months. The native kind of paddy, known as Amman, is grown in the lower portions of Bagerhat, Khulna, and Satkhira districts during the rainy months of July through December following the shrimp harvest (Barmon et al. 2007).

1.2 Coastal Shrimp and its culture in Bangladesh

Coastal shrimp culture is essentially the only indicator of coastal aquaculture in Bangladesh. Once covered in thick mangrove foliage, many coastal districts, including Khulna, Barisal, Patuakhali, Bagerhat, Chittagong, and Cox's Bazar, have been transformed into aquaculture farms. Bangladesh's coastal regions have an environment and climate that are ideal for shrimp farming at relatively moderate production costs. The industry of shrimp culture, which is based on shrimp farming and is entirely focused on exports, was mainly developed in the 1980s. Bangladesh developed several export-friendly policies during this time, which promoted commercial shrimp farming in the country. The World Bank/UNDP investment program of US$ 30 million, which was put into effect in the late 1980s and early 1990s and provided infrastructure, technology, and international assistance to help start Bangladesh's prawn industry, also gave the nation a significant boost (Rahman, 1998). Then, the commercialization of shrimp culture was accelerated by advantageous local laws and a shifting worldwide market.

Figure 1.2: Harvested farmed Tiger shrimp

1.2.1 Major shrimp species from culture ponds/ghers in Bangladesh

Ten of the 25 species of shrimp that have been found from Bangladesh's marine waters are now being used for commercial purposes.

Penaeus monodon, also referred to as bagda chingri in the local dialect, is the species of choice for coastal shrimp farming and commands a premium price on global markets. The gigantic freshwater prawn, *Macrobrachium rosenbergii* (Galda chingri), contributes for 25% of the farmed shrimp production in Bangladesh, with *Penaeus monodon* (Bagda chingri) accounting for 60% of the total (Rosenberry 1995; Ahmed 1996). Other harvested shrimps are naturally introduced by catch.

Table 1.1: Shrimp Species harvested from Gher's of Bangladesh

Serial no.	Local Name	Common Name	Scientific Name
01.	Bagda chingri	Giant tiger shrimp	*Penaeus monodon*
02.	Golda chingri	Giant freshwater White shrimp	*Macrobrachium rosenbergii*
03.	Chaka chingri	Brown shrimp	*Fenneropenaeus indicus*
04.	Horina chingri	Prawn	*Metapenaeus monoceros*

1.2.2 History of Coastal Shrimp Culture in Bangladesh

Bangladesh's shrimp production is mostly centered in the southwest, with Satkhira, Khulna, and Bagerhat accounting for 80% of the country's saltwater Bagda shrimp production. Shrimp farming that is too intensive has resulted in a significant decline in the variety of livelihood options available, as well as decreased resilience and increased community vulnerability. Poverty rates have risen across the region as a result of serious environmental degradation and the monopolization of land by a few large-scale shrimp producers. Since traditional land management methods were changed and land values rose quickly, the fast expansion of shrimp farming has caused land disputes within communities. Eighty percent of farmers in certain villages, according to the participants, leased their property for shrimp cultivation. Thirty percent of those surveyed said they were residing on khas lands in some regions, such as Shyamnagar Upazila. The fact that the people who live there do not legally own the property makes them more vulnerable to being uprooted, and it also significantly reduces their ability to invest in and sustainably manage the land.

Since shrimp farming was introduced, the rice industry, which was formerly the backbone of the local economy, has suffered greatly. Shrimp farming is less labor-intensive, which lowers crop yields and reduces daily work opportunities. Due to a lack of pastoral pastures and rice husk cattle feed, people have difficulty raising livestock. Growing food on a homestead has also grown more challenging. Many communities are experiencing a crisis of clean drinking water as a result of salinized water now seeping into local water tables. As a result, women and children must walk farther to obtain clean drinking water, or they may rely on water vendors or rainwater collecting.

Individuals' health is also being impacted by high salt levels. Due to pollution and the use of salty water for washing, women in particular reported a sharp rise in genital and skin illnesses. Reduced agricultural product diversity has major health effects for rural people as well; meals in shrimp farming areas are said to contain less meat, eggs, milk, vegetables, and fish than they did before to the industry's establishment. Because there is less milk and meat available, the reduction in animal reproduction is especially harmful to children's nutrition. In Khulna district, 49.8%x of children are underweight as a result, according to FAO data. Birth deformities, stunted growth, night blindness, an increase in childhood illness cases, an increase in miscarriages, and higher rates of maternal morbidity and mortality have all been related to poor nutrition in shrimp farming areas. Additional unintended health effects of shrimp aquaculture include a rise in waterborne illnesses brought on by less regular water boiling as a result of dwindling fuel sources like wood.

In the case of shrimp farming, the practice of coastal aquaculture dates back many decades. In Bangladesh's coastal regions, the native population long before the advent of modern shrimp growing techniques engaged in traditional bheri/gher aquaculture (DDP, 1985). During the monsoon, they would go to an aman (paddy) plantation and tap the tidal water in the paddy fields from January/February to June/July for aquaculture. They used to get an adequate amount of shrimp and fin fish in addition to paddy even though there was no fry stocking, artificial feeding, liming, fertilization, or aeration. Early in the 1960s, the government built a lot of coastal embankments to shield coastal agricultural land from saline water incursion and tidal waves. As a result, conventional shrimp aquaculture in these areas was discontinued. By the middle of the 1970s, a few desperate locals forced the embankment to open, resuming the customary Bheri cultural ritual. It all began in the Satkhira district and swiftly extended to the other coastal districts, including Cox's Bazar. Nonetheless, robust global market demand and elevated product prices have incentivized farmers to recommence shrimp farming in polders situated within the embanked regions since the 1970s. The polders had grown so waterlogged from inadequate drainage that it was no longer economically feasible to harvest rice. This was equally significant. The process of increased shrimp farming was sped up by these two elements working together as a catalyst (Karim, 1986). According to Haque (1994), the government of Bangladesh acknowledged shrimp farming as a legitimate business during the Second Five-Year Plan (1980–1985) and implemented the required policies to boost shrimp output. Shrimp farming occupied slightly more than 20,000 hectares in 1979–1980 (Ahmed, 1988), but as of right present, 240,000 hectares (DoF, 2013) are under shrimp agriculture.

1.2.3 Present Trend in Shrimp Culture in Bangladesh

In tidal flats, low-lying areas that are periodically submerged in water, people in Bangladesh traditionally practiced shrimp culture. In the coastal district of Satkhira, shrimp production was traditionally practiced extensively and on a very small scale prior to the erection of the coastal embankments. However, the early 1970s saw the beginning of the expansion of shrimp culture due to the high price and growing demand in the international market. Shrimp output has climbed from 2220 t in 1982–1983 to about 102,877 t in 2011–12, while the shrimp culture area has grown from 20,000 ha in 1980 to over 240,000 ha in 2011 (DoF, 2013). The southern districts of Khulna, Bagerhat, and Satkhira contain about 75% of this area, while the remaining portion is found in the Cox's Bazar district in the southeast. Shrimp and paddy are produced alternately in the rainy season in Khulna districts, and salt and shrimp are produced alternately in the Cox's Bazar area.

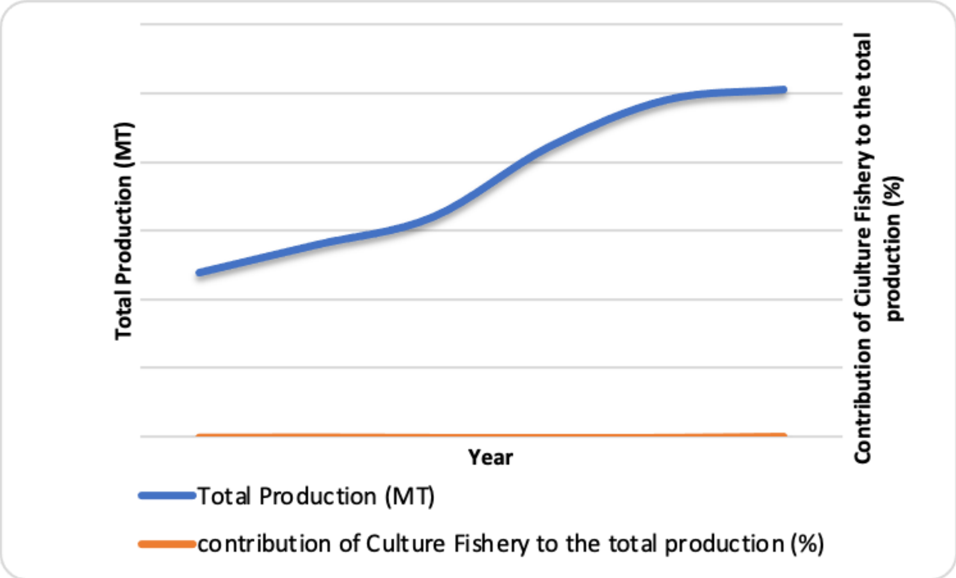

Figure 1.3. Present trend of Fisheries production in Bangladesh and Contribution of Culture Fishery

Most shrimp farms currently use more modern culture technology than those used in the early phases, both as a result of public knowledge and customer desire. However, most farms have frequent issues with water quality as a result of non-scientific management, which leads to extremely low output relative to the total input. Another effect of low water quality is the frequent occurrence of disease outbreaks and shrimp mortality. Shrimp culture strategies that appear to exist in Bangladesh are conventional or extensive, semi-intensive, and intense, depending on the fry stocking rate and the level of management used. The traditional or extensive cultural type is still the most common, notwithstanding advancements. Production ranges from 0.06 to 0.2 t/ha/yr, which is extremely low. The semi-intensive culture variants have stocking densities of two to three juveniles per square meter, exchange around half of the pond's water with each spring tide, provide pelleted feeds but also partially rely on natural meals, and produce two to five tons per hectare annually. Shrimp cultivation techniques have evolved over the past 30 years from "traditional" to "improved traditional," with an emphasis on semi-intensive systems. But the intense farming method is too far away to be put into reality.

1.3 Shrimp in Bangladesh's Economy and Export Trade

Bangladesh's shrimp industry has grown significantly in importance due to its potential to boost the national economy. Shrimp are the largest source of foreign exchange earnings from Bangladesh's fisheries sector (Kashem, 1996), as this industry has made important contributions to the nation's foreign exchange earnings, employment creation, and coastal community development. Since the middle of the 1980s, shrimp farming in Bangladesh has been exclusively focused on exports, with non-local business owners primarily operating on leased territory. Raw jute was the leading primary export product until 1993–1994, when shrimp took over with 57% of exports in the main goods category (EPBB, 1995). The fisheries and aquaculture sectors have emerged as one of Bangladesh's major sources of export revenue in recent decades as a result of rising global demand. Producing more than 2.5 percent of the world's shrimp production, it is currently Bangladesh's second-largest export sector after RMG. In 2011–12, shrimp exports brought in a total of 3640 crore Tk in foreign earnings (DoF, 2013). The production and export trend of shrimp and shrimp-related items is depicted in Figure 4.

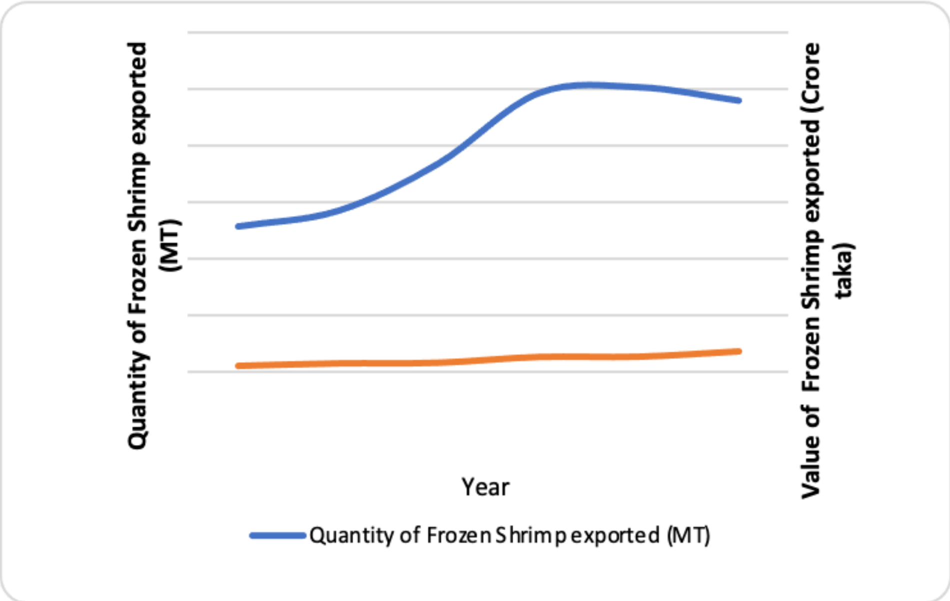

Figure 1.4. Trend in Shrimp export by quantity and value

Particularly for the impoverished in rural areas, shrimp culture is crucial to maintaining food security and reducing poverty. According to a research (FSRFDS, 2003), the shrimp industry employed around 840,000 people directly and another 500,000 people indirectly in 2002. The majority of these workers are women. The growth of the shrimp industry was considered a key strategy for decreasing poverty and promoting pro-poor growth through higher exports and output as well as enhanced performance and competitiveness, according to the government's interim Poverty Reduction Strategy Paper (IPRSP). Shrimp are mostly grown for the global market, and Bangladesh is the seventh-largest producer of cultured shrimp globally, although having a modest share of the global market (4.2% of total shrimp output). The main export destinations are the United States of America (USA), Japan, and the European Union (EU). Of Bangladesh's total shrimp exports, around 55% are sent to the EU, 35% are sent to the USA, and the remaining portion is shipped to Japan.

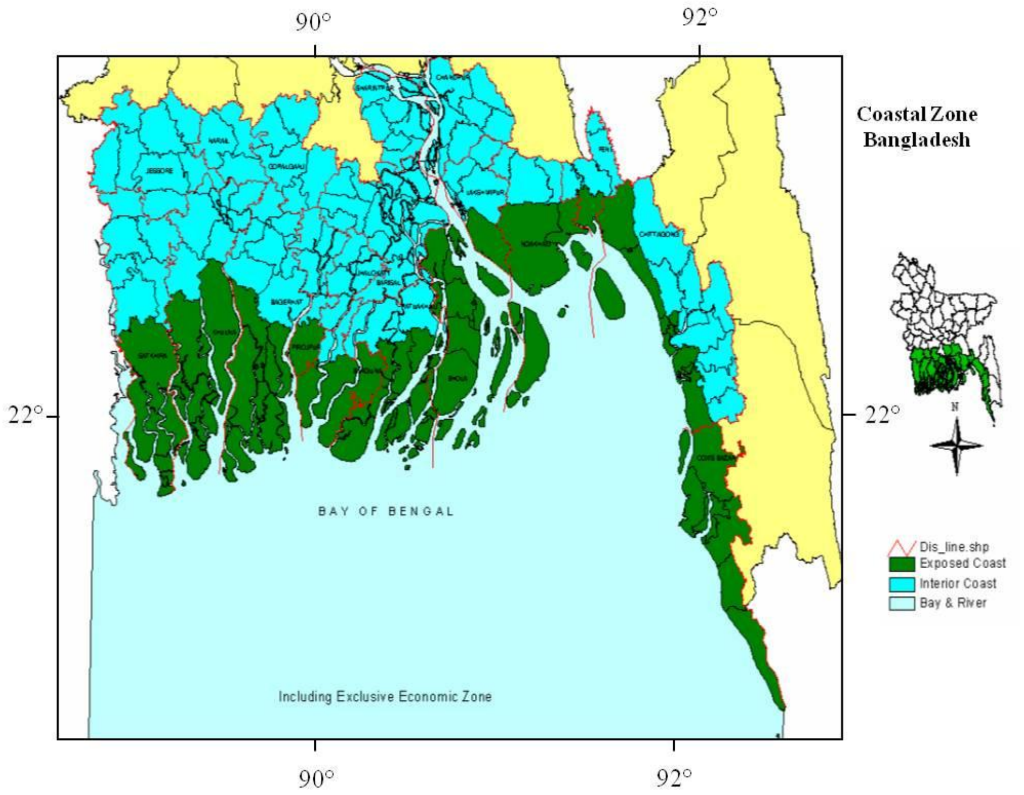

Figure 1.5: Saltwater Shrimp Cultivated Area Map (Source: Department of Fisheries, 2010)

1.4 Major Constrains Regarding Overall Production and Trade of shrimp in Bangladesh

Modernizing the shrimp farming method has certain negative social and ecological effects even though it increases production and maximizes potential. In addition to its ecological effects, modern shrimp farming includes socioeconomic costs (Bailey I988, Primavera 1993, Baird and Quarto 1994; Barraclough and Finger-Stich, 1996). Due to its detrimental effects on the coastal environment, the rapid expansion of shrimp farming and the adoption of extensive and traditional shrimp culture practices have already raised concerns. In most regions, the growth of shrimp production has raised environmental and ecological issues. In addition, a number of limitations hinder the growth of shrimp farming and have an impact on shrimp quality and production. These limitations fall into the following categories.

1.4.1 Land Use and Property Rights Issues

Farmers are bringing additional territory under shrimp farming, drawn by the possibility of large earnings. Consequently, shrimp farming has been introduced to the land that was traditionally utilized for other crops, particularly rice, or left fallow (for grazing). In addition to upsetting the socioeconomic conditions in the impacted areas, it harms conventional agricultural systems. While some people make riches from shrimp farming, a thorough cost-benefit analysis reveals that practically every household loses out on important opportunities due to these costs. Opportunities to cultivate fish in homestead ponds, grow fruit trees, raise poultry and cattle, grow firewood, raise fresh water for drinking, and cultivate cow dung are among those that have been lost. Shrimp farming is significantly less profitable than is claimed if one considers all the benefits that a peasant household receives from various sources (in terms of work, monetary income, and direct consumption). Important questions about the use of land and water in coastal areas have been brought up by the growth of shrimp farming. Conflicts have arisen frequently in shrimp farming areas, generally to the detriment of lower socioeconomic groups, due to the divergent needs of rice farmers and shrimp growers. Poverty rates have risen across the region as a result of serious environmental degradation and the monopolization of land by a few large-scale shrimp producers. Since traditional land management methods were changed and land values rose quickly, the fast expansion of shrimp farming has caused land disputes within communities.

1.4.2 Environmental issues and animal welfare

Farming shrimp raises the salinity of the soil. farming's detrimental usage of chemicals has an influence on biodiversity. One example is shrimp farming. Fields that are flooded with salty water get more salinized and lose their fertility. Traditional fish populations in lakes and canals are destroyed by prolonged flooding, which has an impact on the impoverished people's ability to support themselves by using these shared water resources. Fish supplies are depleted by fine-meshed nets used to collect shrimp fries. Because catchers only keep the shrimp larvae, this also leads to ecological imbalances that alter the mix of species. The rest of the species are exterminated. The dependence of shrimp farming on the gathering of wild shrimp fry poses a challenge to its sustainability. By adopting inexpensive and destructive methods, this activity currently supports a significant number of households and provides shrimp farms with seed inputs, but it may also be seriously harming wild stocks of shrimp and other aquatic species.

1.4.3 Social Issues:

Shrimp farmers receive a disproportionate share of the money, which is significantly skewed in their favor. In the larger Khulna district, two percent belong to wealthy local landowners, ten percent are small and marginal farmers, and seventy percent are owned or managed by foreigners, according to a recent assessment. The low yield statistics clearly show that shrimp entrepreneurs typically increase their profit margins by growing the cultivated area rather than intensifying it. The impoverished are frequently forced to give up their lands in order to further the growth of shrimp farms. The labor needs for shrimp farming are lower than those for rice production. In addition, outside contractors provide the majority of the labor. As so, a large number of people—men primarily—are compelled to relocate in order to find work. This forced migration puts more responsibility on women in addition to causing emotional strain within the family. A significant decline in varied livelihood possibilities, a drop in resilience, and an increase in community vulnerability have resulted from intensive shrimp farming.

1.4.4 Human Health Hazard

Many towns are experiencing difficulties related to clean drinking water as saline water is now seeping into the local water tables. Women and children are consequently compelled to walk farther to obtain clean drinking water, or else they must rely on rainwater collecting or water merchants. The health of humans is also being impacted by high salt levels. Particularly among women, there has been a noticeable surge in genital and skin illnesses as a result of pollution and washing with salted water. The decrease in the variety of agricultural goods can have detrimental effects on rural people' health, as meals in shrimp farming areas are said to contain less meat, eggs, milk, vegetables, and fish than they did before to the establishment of the industry. Because there is less availability of milk and meat for children to eat, the reduction in animal reproduction is especially harmful to their nutrition. Consequently, 49.8% of children in the Khulna district are underweight, according to FAO data. In areas used for shrimp farming, inadequate nutrition has been connected to increased rates of childhood illnesses, miscarriages, maternal morbidity and death, stunted growth, night blindness, and birth deformities. Additional unintended health effects of shrimp aquaculture include a rise in waterborne illnesses brought on by less regular boiling of water since there are fewer fuel sources, such as wood.

1.4.4 Problems at farm level

The shrimp farming industry in Bangladesh has been expanding horizontally during the past few years, but regrettably, inadequate management techniques have prevented the attainment of an adequate level of shrimp production. According to Hoqet al. (1997), low production rates, which range from 197.4 to 225.6 kg/ha/season, and bad management practices are the main obstacles to competing in the global market and, as a result, preventing the nation from generating enough foreign cash. According to Karim and Aftabuzzaman (1995), the majority of shrimp farms in Bangladesh use outdated and inefficient farming techniques. Additionally, it is challenging to implement newer, more efficient culture technologies on these unmanageably large, irregularly shaped, and shallowly shallow farms. A well-managed system at different cultural practices is essential for the success of shrimp farming. Conclusively, the commercial growth of shrimp and prawn farming is, in terms of volume production, nationally negligible, although being geographically broad but fragmented in nature, with a few notable exceptions. Evaluating employment generation and personnel engagement in shrimp farming, as well as estimating production, marketing system, and channel were the study's objectives. The future viability of shrimp production and shrimp farming development is at risk if there is insufficient hatchery development to meet the needs of the sub-sector.

1.4.5 Issues facing the conventional Bangladeshi shrimp value-chain

A. Quality and Traceability:

B. Insecurity and helplessness of the shrimp farmers:

Although prices are discussed between retailers and processing facilities, there is very little negotiation between fry collectors and middlemen at the bottom end of the value chain. Small farmers have very limited power to influence prices and are frequently dependent on larger, more powerful purchasers.

1.4.6 Problems in local market in general

The issues are listed in the following order (modified from Nupur, 2010 and others).

- Absence of high-quality PL lack of seed certification.
- Inadequate water management; unplanned growth of shrimp and prawn gardens; and infrastructure issues
- There are no distinct areas for shrimp and prawns.
- Farmers are ill-equipped to recognize diseases and take precautionary action.
- Lack of technical expertise in prawn and shrimp production, inadequate training, poor feed quality, insufficient ingredients, and expensive costs, poor quality ice and farmers' unfamiliarity with using it during transportation, and absence of the necessary vehicle.

- Increased number of middlemen in the marketing channel Insufficient water source as a result of siltation in the river and canal…
- Insufficient communication and inadequate power supply.
- Reduced quality of illegally produced shrimp and prawns.
- Farmers are not receiving their full price because processing plants control the market price.
- Unclean baskets used to transport shrimp and prawns from the farm; and a lack of current marketing information at the farmer level

1.4.7 Problems in export market in general

The issues are listed from literature (modified from Rahman and Hossain, 2009 and others)

- Decrease the quality of shrimp and prawns obtained illegally.
- Use cow dung, chicken drop, poultry feed, etc. as shrimp and prawn feed in farms.
- Failure to implement traceability and HACCP at all stakeholder levels.
- The absence of equipment and trained personnel to detect illnesses and antibiotics; dishonesty in business (at all levels); adultery; noncompliance with regulations regarding the handling of shrimp and prawn.
- Control over the price of shrimp and prawn set by processing plants and nonpayment of invoices on time; noncompliance with the Fish and Fisheries Inspection and Quality Control Act 1997; the presence of antibiotics (e.g., chloramphenical, nitrofurans) in prawn and the EU's unfavorable stance towards Bangladeshi shrimp exports
- If the traceability issue is well managed, there is a good chance that prawns will be exported to other countries.
- There are a number of restrictions, such as those related to the environment, food security, and the white spot illness that affects shrimp.

1.5 The selection of Bagerhat shrimp farms area

Bangladesh's southern border is home to abundant marine and coastal resources. The country's coastal region is regarded as one of the world's most prolific regions because of its unique geographic location and climate. Bangladesh's top shrimp farming regions are the South-Western districts of Bagerhat, Khulna, and Satkhira; the South-Eastern district of Cox's Bazaar; and the South-Central district of Pirojpur, to a lesser extent. Today, shrimp production in Bangladesh is highly concentrated in the South-West, with Satkhira, Khulna, and Bagerhat producing 80% of the country's bagda (saltwater) shrimp. The majority of prawn and shrimp farms (~75%) are located in the South-West part of the country, mainly in the districts of Bagerhat, Khulna, and Satkhira. The remaining shrimp farms are in the South-East region, including Cox's Bazar and Noakhali district. Over the past ten years, shrimp farming has grown remarkably quickly and contributed significantly to foreign revenues. The area used for shrimp aquaculture encompassed around 2, 75,232 hectors by 2011–12. Geographically, the Bagerhat area is located in a region with a varied climate that includes freshwater, brackish water, and maritime conditions. Fresh prawns and marine shrimp can both be grown successfully in this terrain. Each year, Bagerhat alone yields a substantial amount of shrimp.

1.6 Scope and limitation of this study

The research employed the most recent land use maps (1995 and 2010), which were released by LGED (Local Government Engineering Department), to identify the land use shift for shrimp agriculture.

The study objectives have been met by a number of policies and papers, and the corresponding departments have contributed to the accuracy of the research report. The gap between policies and traditional shrimp farming practices has been explored by the international policy for sustainable shrimp farming (2006), the national fish policy (1998), the private fisheries protection act (1899), the government fisheries protection ordinance (1959), the protection and conservation of fish act (1950), the national environment policy (1995), the shrimp mohal management policy (1992), and the national land use policy (2001). These documents have been gathered with ease. Farmers have generously contributed to the data collection. These records and diagrams contribute to a meaningful and instructive description of the research.

The lack of the 2014 land use map from the LGED (Local Government Engineering Department) is one of the research's shortcomings. Data collecting for the adverse weather has taken a long time, and while prior studies have looked into various problems, no particular research has looked into possible locations for shrimp farming.

The study perspective placed great importance on the area chosen, yet frequent data collection and cross-checking could occasionally be hindered by local political influence.

1.7 Rationale and objective of the study

Bangladesh ranks among the world's leading producers of farmed shrimp, with Thailand, China, and Indonesia rounding out the top three. The production of shrimp (primarily *Penaeus monodon*), which is primarily grown in Bangladesh's southern coastal belts, has more than doubled in the last ten years, from approximately 1,16,655 MT in 1995–96 to approximately 2,52,523 MT in 2011–12. Cultured shrimp and prawns contributed 30.02% and 54.32% of this total, respectively (DoF, 2013). For Bangladesh's fisheries industry, shrimp culture is essential. From virtually nonexistent in the early 1970s, it increased to roughly 11% of all exports by the mid-1990s (DOF, 1995). No other major commodity in Bangladesh saw such phenomenal expansion after independence. Conventional shrimp farming has certain detrimental effects on the environment and society in addition to providing Bangladesh with foreign exchange and financial gains for the farmers. Three factors affect the effects of shrimp farming: the environment, society, and economy. A lot of individuals think that growing shrimp is a great way to generate foreign exchange and more work possibilities. However, a few obstacles prevent this industry from growing and significantly lower predicted production. For example, Bangladesh's shrimp production is highly developed, extensive, and requires little capital inputs due to its low yield per hectare. If these limitations are correctly identified, actions may be done to lessen them, and our shrimp output will undoubtedly rise to the desired level. Thus, the purpose of this study was to identify any barriers to the predicted level of shrimp production in the Bagerhat district.

1.7.1 General aims of the proposed research work

It is crucial to identify the issues in order to maintain farming and increase output across the region. This includes identifying and determining the elements that contribute to the growth performance of tiger shrimp and the unbalance of the farming environment. The purpose of the suggested idea is to both identify and quantify the factors that have an impact on the farming environment and how they affect the overall productivity.

1.7.2 Specific objectives

The following goals were pursued by the research:

- Assessing production variation among several *gher* fish culture.
- Determining which best production techniques to be established.
- Identification of the impact of social factors on shrimp farm productivity.
- Determining the influencing elements that improved the area of research tiger shrimp farms' output.

Chapter 2. Literature Review

2.1 Global Aquaculture and Challenges

The principal challenge of global aquaculture tends to mitigate the supply and demand of fish and fisheries products in paralleled with the outbreaking population growth in the world. The FAO (2018) reported that the total aquaculture production including the aquatic plants for 2016 was 171 million tonnes (Figure 2.1), with aquaculture representing 47 percent of the total and 53 percent if non-food uses (including reduction to fishmeal and fish oil) are excluded. The total first sale value of fisheries and aquaculture production in 2016 was estimated at USD 362 billion, of which USD 232 billion was from aquaculture production.

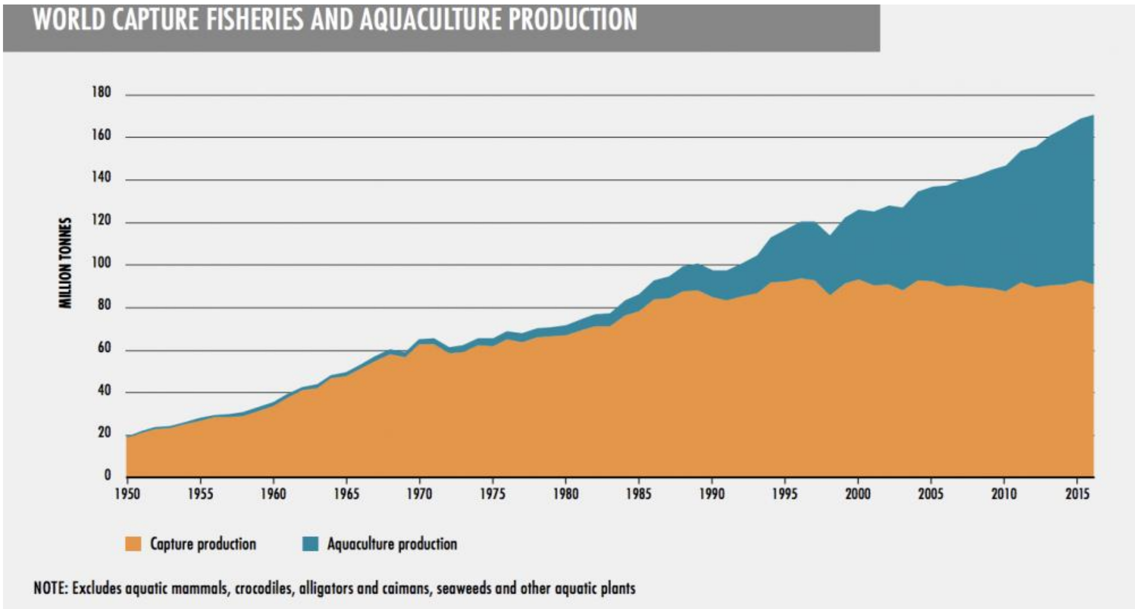

Figure 2.1: A graph showing the present fisheries production both capture and culture

The State of World Fisheries and Aquaculture (FAO, 2018) reported that the world food fish aquaculture production decreased at an average annual rate of 5.8% in the period of 2000–2016, although double-digit growth still occurred in a small number of individual countries, particularly in Africa from 2006 to 2010. Global aquaculture production in 2016 included 80.0 million tonnes of food fish and 30.1 million tonnes of aquatic plants, as well as 37 900 tonnes of non-food products. Farmed food fish production included 54.1 million tonnes of finfish, 17.1 million tonnes of molluscs, 7.9 million tonnes of crustaceans and 938 500 tonnes of other aquatic animals. China, by far the major producer of farmed food fish in 2016, has produced more than the rest of the world combined every year since 1991. The other major producers in 2016 were India, Indonesia, Viet Nam, Bangladesh, Egypt and Norway. Farmed aquatic plants included mostly seaweeds and a much smaller production volume of microalgae. China and Indonesia were by far the major producers of aquatic plants in 2016. Nevertheless, comparison to the projected population by 2030, an additional 40 million tons of fish and fisheries production will be requiring to maintain the present per capita consumption. Therefore, this sector is going to face some challenges, which are already adopted. Presently, aquaculture is thought to be the fastest growing food producing sector, and is perceived as having the greatest potential to meet the growing demand for aquatic food. Analyzing the future challenge in the fisheries sector, Food and Agriculture Organization (FAO) has scrutinized the following challenges which include:

1) The present aquaculture is growing with special attention for maintaining the food security, mitigating the unemployment, involving to develop the national economy including recreation. The success rate of aquaculture varies with the geographic location, market access and the affordable technology through taking some specific interventions which allow the maintain the production in a sustainable way;

2) The baseline data collection method is needed to be strengthening by evolving the scientific and social assessment concerning management and development option. It includes a) making consultation with the data users particularly extension workers and managers, so that they can perform their work perfectly; b) introducing the need base appropriate data collection method as well as data management system; c) ensuring the national commitment for the production of fish and fisheries without any conflicts as well as to ensure from the national management body for sharing the data; d) involving the relevant organizations like FAO and non-FAO regional fisheries stakeholders and other appropriate institutions and organizations which are the part and parcel of the regional fisheries production both in capture and culture;

3) The intensification of present aquaculture needs to get support from all sectors particularly the improvement between the government and private sectors. The is the most difficult part or challenges in present intensified aquaculture.

4) The most important challenge is to ensure to participate all relevant stakeholder and communities to make decision. This is specially for community based aquaculture management and co-management practices of common aquaculture pool;

5) Need to improve easy access, dissemination the good quality information timely using appropriate formats, in support of responsible aquaculture, and it's trade

6) The fishing gears are widely used in developing countries. The rules adopted for using the fishing gear are still needed to improve and impose during harvesting;

7) The fish trade is needed to promote with a view to avoiding disputes and imposition of sanctions; minimizing the impact on international fish trade on those groups most vulnerable to food insecurity;

8) The integration of the fisheries resources management is needed to develop in a sustainable way;

9) Need to adopt new technology, ensuring seed, feed (free of antibiotics) and fertilizer in terms of quantities and qualities;

10) Need to minimize the production loss through improvement in fish health management using need feeding strategies based on the culture fish;

11) Need to maximizing the source of feed ingredients with minimum cost and to minimize the severe completion of aquaculture resources use;

12) Need to maintain the good water quality for target aquaculture fishes;

13) Need to adopt integrate aquaculture management supporting with other farming activities creating an integrated new approach for low income target beneficiaries;

14) Need to take necessary action for improving the environmental management of aquaculture particularly the fish growth and health in terms of climate change;

15) Need to ensure to follow the international rules and regulation during operation of inland aquaculture that make the assurance of food safety to the final consumers.

In order to mitigate these challenges, the aquaculture sector must develop the capacity to build and run effective quality assurance systems to comply with increasing stringent international standards of international markets as well as extending these to the domestic markets. Similarly, it should promote efforts to improve selective feeding technologies to make economical utilization of fishes.

2.1 Bangladesh Aquaculture Status, Challenges and Opportunities

Bangladesh is endowed with vast marine, brackish and inland waters having plenty of fisheries resources. It has 720 km long coastal line along southern part of the country facing Bay of Bengal. Contribution of fisheries in the national economy of Bangladesh is substantial, particularly with reference to food consumption, nutrition, employment and export. Though Bangladesh is largely agrarian, analysts have identified the fish and seafood sector as a core component of the country's economic development (FRSS, 2017). The fishery and aquaculture industries play a decisive role in the Bangladeshi economy, supporting millions of jobs and providing reliable foreign export earnings. In 2018, Bangladesh was the fifth largest global aquaculture producer and the sector is expected to continue growing in the coming years (FAO, 2018). Economists expect Bangladesh to come out of the low-income country category and move into the lower-middle income category within the next seven years – aquaculture exports will play an instrumental role in the transition. The total fish production has been increased dramatically in the past two decades, starting from 1.781 million metric tonnes in 2000-2001 and reaching 4.134 million metric tonnes in 2016-2017 (FAO, 2018).

The 21st century reveals a fishery management process experiencing unprecedented socioeconomic, environmental and institutional challenges. Over the last fifty years, fisheries governance has rapidly evolved from primarily open access to regulated common property and rights-based institutions (DOF, 2014). The inland capture fisheries sector faces habitat degradation through agricultural development, urbanization and development of industries. The breeding ground for capture fishery resources has been affected by many environmental and man-made factors. Moreover, substantial industrialization and urbanization cause water pollution problems that subsequently affect the fisheries resources. The opportunities for capture fisheries restoration and rehabilitation may be realized by bringing an increasing area under co-management where fisheries are managed responsibly, optimizing the use of water bodies for fish production and raising the voice of the sector during environmental impact assessments. The challenges are to gradually bring the small-scale sector under co-management arrangements with the long-term aim to control inputs and to reserve resources for the small-scale sector through zoning. Aquaculture is a growth sector in Bangladesh. There is still a vast potential for development of the sector, but it will increasingly meet resistance from and be competing with agriculture. Pollution from fish farming and also the impact of pollution on fish farming are becoming important issues. Responsible development of the aquaculture sector may cause a growth in availability of high-value animal protein for the growing local population as well as for an expanding export market.

Perspectives for the fishery sector over the coming decade suggest that with the right mix of policy and investment, the potential can be good, inspite of increasing constraints, such as population pressure, habitat destruction, construction and industrial development, and environmental challenges. Based primarily on growth in aquaculture and adding value to the capture sector, increased output and corresponding gains in value and employment could be envisaged. To meet the required fish protein and to ensure the food security of the increasing population, a pressure on culture fisheries has already been noticed since capture fishery production cannot be increased further.

2.2 Bangladesh Shrimp Cultivation Trend

The starting point of shrimp cultivation could be identified from 1930s and commercial shrimp cultivation began worldwide in the year 1970s. In 1979, the growth of shrimp cultivation was not measurable scale. In 1980’s the profit of the shrimp business began to attract the benefit of leading forces of Bangladesh. From 1990 to 1994, shrimp cultivation became the alternative income source of the farmers and export-oriented business. Europe and USA are the main client of salt water shrimp. Exports of shrimp increase from US$ 90.8 million in 1986 to US$ 197.6 million in 1994 and to US$ 260.4 million in 1998.The fisheries sector including shrimp, contributes about 6% to the national GDP and 5% to the national export earnings. Shrimp alone contributes about 93% of sectoral export earnings and 4.99% of the national earning item in Bangladesh. From 1995 to present, salt water shrimp is the pioneer economic activities of coastal part of Bangladesh. Shrimp cultivation demands salt water. So, the shrimp farms are spreading the saline water in the distributaries rivers, wetlands and pond. The salinity of the cultivated land has increased around 21% within the last three decades in the southwest coastal area. In 1973, only 14% of saline land was in the highly saline category, whereas in 2000, it reached 443.9%. Consequently, salinity encroachment has been hampering the crop production and reducing food security. The expansion of salinity through shrimp cultivation has been endangering the livelihood of the SW (South western) coastal region. At present, at least 100,700 hector areas is covered by shrimp farms in Satkhira, Khulna and Bagerhat area. Around 56% of the rivers in this area are contaminated by salinity (Islam, 2009). Water logging and salinity has caused the death of most of the vegetation in the region, rendering this once bountiful land into a watery desert. Moreover, the shrimp producers keep on adding extra salt into the water during heavy monsoon rainfall to ensure better growth of shrimp which increases the level of soil salinity. The local people have identified two most important problems due to extensive shrimp farming in their localities. One problem is the depletion of fisheries resources and other one is the reduction of plants and trees that affect their lives, livelihood and environment. The rapid growth of the unplanned practice of shrimp farming has drastically reduced the mangrove forests and destroyed the breeding habitat for many fishes and hampering the traditional livelihood practice as well as creating social conflict among the local communities within the Sundarban Impact Zone (SIZ). As the profits from industrial shrimp farming is comparatively high, the rural elites and the urban influential investors introduced shrimp farming without concern of environment (Rahaman, 2005).

Bangladesh is world's fourth largest producer of fish sourced from inland water bodie. Exports of shrimp from Bangladesh were worth only US$ 2.9 million in 1972-73, accounting for one per cent of the country's total exports. Exports of shrimp increased to US$ 33 million in 1980 and to US$ 90.0 million in 1985 (Frankenberger, 2008). However, until the mid-1980s shrimp culture was principally dependent on open-water catches of shrimp. Thus, the culture of shrimp through commercial farming is predominantly a development of the period beginning from the mid-1980s **(**Alam, 2008**).** The policy initiatives and the incentives, many of which were implemented under the SAP (Structural Adjustment Policy). Actually SAP (Structural Adjustment Policy) has been implemented by the International Monetary Fund (IMF) and the World Bank in developing countries for improving the country status but by implementing the policy, Bangladesh loss sector wise development and fully depends on the foreign fund. So, in the mid and late 1980s, set the context in which shrimp culture in Bangladesh started to attain the characteristics of a major, export oriented economic activity. Exports of shrimp registered an increase from US$ 90.8 million in

1986 to US$ 197.6 million in 1994 and to US$ 260.4 million in 1998. A visible shift is discernible in the trend line for shrimp exports during the post SAP (Structural Adjustment Policy) period, reflecting structural changes induced by reform policies. Extensive shrimp cultivation is the root cause of environmental degradation and livelihood insecurity **(**United Nation Environmental Program, 2003**).**

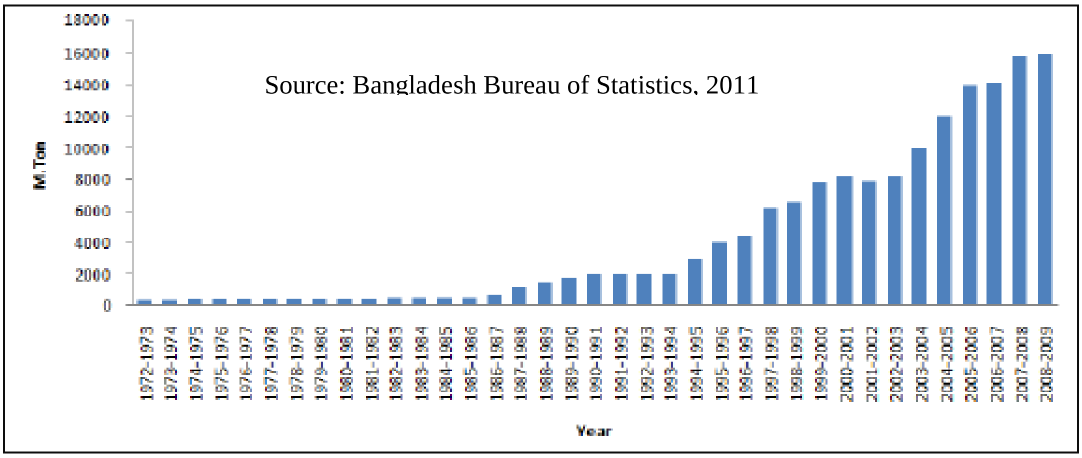

Figure 2.2: Export Trend of Cultured Shrimps in Bangladesh from 1972-73 to 2008-09 (BBS 2011)

Figure 2.2 shows, in 1972-1973 shrimp cultivation started on experimental basis. As it was a profitable business, in 2000 to 2001 it shows a measurable economic activity. During this period, there was no concern of environment because land was available. Since 2007 to 2009, the negative impact of shrimp cultivation on land, environment and society were noticed.

2.3 Cultured Species of Shrimp in Bangladesh

A total of 25 species of shrimp have so far been identified from the marine water of Bangladesh, of which 10 species are commercially exploited (DoF, 2005).

Among these species *Penaeus monodon* (locally known as Bagda chingri) is the preferred species for coastal shrimp farming and attracts a very high price in international markets. In Bangladesh, *Penaeus monodon* comprises 60% of farmed shrimp production, followed by the giant freshwater prawn, *Macrobrachium rosenbergii* (Galda chingri) which accounts for 25% of production (Rosenberry 1995; Ahmed 1996).

2.5 Impact of Shrimp Cultivation

The impact of shrimp cultivation has felt on the various sectors. Like agriculture, land, environment, society and over all livelihood. Because all sectors are inter related with one another. Firstly shrimp cultivators have entered saline water to the agricultural land and degraded land, water body, wet land, settlement and forest. Then it has felt negative impact on fish and paddy production. Biodiversity has changed. Over all environments has been degraded. Land conflict and crime increased in the society. Local Government could not able to control by regulations. Regional economy has changed. It has felt negative impact on food security. (United Nation Environmental Program, 2003).

2.5.1 Land Degradation:

The main shrimp cultivated districts are Khulna, Satkhira, Bagerhat, Barisal, Cox's Bazaar, Patuakhali, Jessore and Noakhali district and cultivation of food and cash crops has totally or partially been eliminated in these areas **(**Murtaza, 1994**).** Poor land use planning, lack of implementation of the Govt. regulations have extended the uncontrolled expansion of shrimp farming in coastal areas. The output of shrimp production is not similar with agriculture production. In the monetary scale, the shrimp production brings more economic benefit than agriculture. So, in the less awarded society, shrimp farming is the first priority beside agriculture. Here land degradation issue is negligible. Land has lost its production capacity for long term shrimp cultivation at Raghunathpur Union (Rahman, 1995).

Shrimp farming has adversely affected the potential crop-mix, cropping intensity, crop calendar and the overall cropping pattern in the areas. Shrimp farming has increased the salinity of soil, canals and the ponds within the polders and higher salinity levels have reduced the land area available for grazing and, consequently, the scarcity of food has lead to a reduction of livestock because access salinity destroy the land and its production (Department of Fisheries, 1995).

The wetland communities of the SIZ (Sundarban Impact Zone) have been living in harmony with wetlands for nearly 500 years. The livelihood survival of the wetland community is linked with the forest resources of the Sundarbans, aquatic resources of the saline and fresh water wetlands. The negative impact of shrimp farming on the land is manifested through salinity and water logging (Economic and Social Commission for Asia and the Pacific, 1989). The net effect of salinity in water and water logging is land degradation through a loss of soil fertility, which leads to reduction in production, irreversible damage to traditional economic activities and at the end makes livelihood endangered. Ecology of the Wetlands becomes damaged. Wetlands are turning into water logged areas due to unplanned shrimp farming (Manju, 1996).

2.5.2 Violation of Human Rights

Some of the shrimp cultivators are the local muscleman, political leaders and powerful persons. They show their power by occupying and for shrimp cultivation and want to make people as labour. They enter saline water to the agricultural land then it falls negative impact to others land. When they protest then they show their power by various crimes. The shrimp farming has been promoting a continuous process of violating human rights. The shrimp farmers engaged musclemen to protect their farms and these musclemen killed people who raised voice against shrimp farming, raped women and exploited labors paying low wages. At first they occupy the agriculture land of the comparatively medium class and poor people and force them to sale or lease the land. Then they enter saline water in the land and the land lost its production capacity. Then they use their musclemen and corrupted Government officer to violet the villagers (*United Nation Environmental Program,* 2003).

The land that was previously used for other crops (especially rice) or remained fallow (grazing land) and other purposes has been brought under shrimp farming. So, all over the year various types of conflict are occurring in the study area (Department of Fisheries, 2010). Outer and local powerful people occupy the agricultural land or others land and turn to shrimp cultivation. Here victims are the local people. Lack of good governance, the responsible departments ignored their duties and handshake with the shrimp farmers. In this way, all types of land go out under shrimp cultivation without concern of any social and environmental considerations (Centre for policy dialogue, 1998).

2.6 Policies and Acts

National and International policies have developed for sustainable shrimp cultivation. The policies formulated on production process, preserving environment, economical benefit, suitable site of shrimp farm and over all sustainable shrimp cultivation. Responsible department are practicing these policies. But reality is conflicting. National policies, International policies and field level execution have a gap. (Rahaman and Quddus, 2006).

2.6.1 National Policies

Shrimp cultivation policy started at 1950 by protection and conservation of fish Act. The policy has formulated on the basis of economic profit. Impact on environment and location of shrimp farm was absent. Next policy was "The Government Fisheries Protection Ordinance, 1959". The main concern was protection of government khas water bodies against unauthorized fishing. From 1980 to 2000, various policies have prepared but specific design standard for shrimp cultivation is absent. Following are the national level policies.

The Protection and Conservation of Fish Act, 1950: Protection and conservation of fish and fisheries.

The Government Fisheries Protection Ordinance, 1959: Protection of government khas water bodies against unauthorized fishing.

The Fish and Fish Products (Inspection and Quality Control) Ordinance, 1983: Empowerment of Government for inspection and quality control of the unplanned fish practice and fish products.

Marine Fisheries Ordinance, 1983: Regulation of licensing, gears and areas of fishing. Jurisdiction is limited from the 18.29m depth line to the limit of territorial waters.

The National Fish Policy 1998: Conserve inland aquaculture and management of closed water bodies.

Private Fisheries Protection Act, 1899: Protection of private fisheries and the rights of landowners who don't like to lend their land for shrimp farming.

The Fish and Fish Products (Inspection and Quality Control) Rules, 1997: Empowers officers and sets licensing systems for processing and export. Provide detailed procedures for inspection and quality control of fish and fish products during transportation, land use processing and export.

The Protection and Conservation of Fish Rules, 1985 & Amended Rule 8(1A), 2000: Ban on catching fry or post larvae of fish shrimp and prawns. The amendment 8(1A) conflicts with National Fish Policy, 1998 & the Embankment and Drainage Act, 1952

National Environment Policy, 1995: Protection of the environment & ecosystem from unplanned shrimp cultivation at the coastal belt.

The Environment Conservation Act, 1995 & Environment Protection Rules, 1995: Provision for environmental clearance.

Forest Act, 1927: Allocation of Fish Management Responsibilities in Mangrove Areas to the Forest Department.

National Water Policy, 1998: Details of multispectral water users' needs approach.

Shrimp Mohal Management Policy, 1992: Identification and declaration of shrimp areas.

Registration of Shrimp Gher/ farm, 1998: Keeping records of shrimp farms.

National Land use Policy, 2001: Allocation of land for shrimp culture and land zoning.

Industrial Policy, 1999: Declaring frozen food industry a "trust sector".

Export Policy, 1997-2002: Promotion of export and consequent promotion of shrimp culture.

The Shrimp Cultivation Tax Act, 1992: Establishes rules for tax on land used for shrimp cultivation with Water Development Board in an appraising role for fixing tax rates.

2.6.2 International Policies

International policies for responsible shrimp farming 2006, describe the policy guidelines have declared for locational choice, farm siting and design. The policy emphasized on the preservation of environment and habitat beside the economic profit from shrimp cultivation. Shrimp farming is one of the fastest growing aquaculture sectors in many shrimp farming is one of the fastest growing aquaculture sectors in many parts of the world and also one of the most controversial. Rapid expansion parts of the world and also one of the most controversial. (Food and Agricultural Organization, 2006).

International principles:

- ❖ Build new shrimp farms above the inter-tidal zone.
- ❖ No net loss of mangroves or other sensitive wetland habitats.
- ❖ Do not locate shrimp farms on sandy soils or other areas where seepage or discharge of salt water may affect agricultural land or freshwater supplies.

- Do not locate new shrimp farms in areas that have already reached carrying capacity for aquaculture. Capacity for aquaculture.
- Retain buffer zones and habitat corridors between farms and other users and habitats.
- Obey land use and other planning laws and coastal management plans.
- Improve existing farms in intertidal and mangrove areas through mangrove restoration, retiring unproductive ponds and increasing productivity.
- Execute punishment for violating land use regulations.
- Follow international standard for shrimp farm siting and design.

2.7 History of Shrimp Culture in Bagerhat

Prawn and tiger shrimp are generally called shrimp in the southern part of Bangladesh. In this region, freshwater aquaculture is virtually limited for the farming of *Macrobrachium rosenbergii* (prawn) and brackish water aquaculture of *Penaeus monodon* (tiger shrimp) together with carps or integrated culture with paddy. *Macrobrachium rosenbergii* is one of the most commercially valued species for aquaculture (Mitra et al., 2005). It is widely distributed in freshwater as well as in brackish water, mainly in ponds, rivers, canals and estuaries (Ahmed, 1957). There are about 81 species of shrimps including *M. rosenbergii, P. monodon, P. merguiensis* and *P. durarum* are available in southeast Asian countries. However, *P. monodon* and *M. rosenbergii* have got great aquaculture potential and commercially cultured in Bangladesh (Akand and Hasan,1992). Presently prawn is commercially cultured in the costal districts and these areas have become the centers for prawn farming in Bangladesh. Moreover, there is 710 km long coast line along the south-eastern part of our country. In this vast area of brackish water body, tiger shrimp culture has been expanded. Bagerhat district is one of this area where tiger shrimp farming has been cultured extensively in Rampal, Mongla and a portion of Fakirhat Thana (Khanom, 1999). According to Islam (1999), the culture area of prawn is estimated as 6,000 hectares of which 3,261 hectares are located in Bagerhat district, whereas 1,429 hectares in Fakirhat Thana. Earlier most of the farmers used to cultivate their farms by traditional method. But now a day most of the farmers' culture shrimps in their farms by traditional, improved traditional or semi-intensive methods. Although there is a bright prospect of tiger shrimp culture in our country, planned action program has not yet been taken. For tiger shrimp culture most of the farmers' act as small land holder. If they are provided with technical assistance production of shrimp can be increased manifolds. Commercial prawn farming has recently taken place in Bagerhat area in ghers.

The gher is an enclosure made for shrimp cultivation by modifying rice-fields through building higher dikes around the fields and excavating a canal several feet deep inside the periphery of the dikes to enter water during the dry season (Kendrick, 1994). According to DFID (1997), gher farming can be considered as a method of combining aquaculture and agriculture on one plot. During the rainy season the whole water body is used for cultivation of shrimp and fish. However, during dry seasons the trenches are used for shrimp and fish culture and rice is planted in the central plot. Shrimp especially prawn can be cultured with carps in low lying paddy fields, shallow ponds, shallow portion of baor, canal beside road and rail line and irrigated canals of fresh water bodies (Chandra *et al*., 2010). Shrimp yield in ghers can be increased by applying modern technology such as intensification of culture operation through regularization of gher size, stocking density, adding aeration system, application of fertilization and feeds.

2.8 Impact of the production of tiger shrimp

2.8.1 Global Context

The shrimp aquaculture industry is a large international business being farmed in 50 countries globally (Kanduri and Eckhardt, 2008), currently producing 55 percent of the world's shrimp (WWF, 2016), with the vast majority of countries and production located in the developing world. Leading producers (in order of production) are China, Thailand, Indonesia, India, Viet Nam, Brazil, Ecuador and Bangladesh. Growing consumer demand for shrimp is fueling an environmental crisis in some of the world's poorest nations.

The Environmental Justice Foundation (EJF, 2014) linked shrimp farming with significant environmental damage, including the large-scale conversion of ecologically sensitive and important wetland areas and farmland. Destruction of mangroves for shrimp farming has been publicly condemned by the United Nations Environment Programme (UNEP, 2010), which stated that "Vast tracts of mangroves have been cleared for shrimp aquaculture, allowing fast profits but leaving long-term debts and poverty which are hard to reverse". The unregulated seizure and conversion of traditional farm land to shrimp aquaculture has put food security at risk and left many of the vulnerable people of the coast without alternative livelihoods. Shrimp farming has been dubbed as "good for the rich and bad for the poor", particularly with regard to food and livelihood security (Hensler, 2013). More generally, high global demand for shrimp as a low-priced, low fat, high protein source of food has driven an industry that has often outpaced the development of environmental and labour standards in producer countries (Accenture, 2013).

2.8.2 Shrimp Farming and Environmental Issues in Bangladesh

Shrimp farming in Bangladesh has been recognized as a part of the Blue Revolution (Kabir and Eva, 2014). Since the introduction of commercial farming, shrimp has been the subject of significant international and national debate. The debate in Bangladesh has often been highly political and, at times, a source of conflict in coastal rural communities. The central issues identified are environmental sustainability, pro-poor economic growth, access to resources, and human rights abuses (Khan and Azad, 2014). Fisheries in Bangladesh in 2012–13 was one of the major contributors to the agricultural GDP (23.37 percent) and to overall GDP (4.37 percent). Within this sector, shrimp (*Penaeus monodon*) is the dominant contributor (DoF, 2014). However, in parallel with its large contribution to local and national economy, it has been suggested to cause significant damages to local ecosystems (EJF, 2004; Paul and Vogl, 2011). Attracted by prospects of high incomes and economic prosperity, farmers have brought hundreds of acres of lands under shrimp production, most of which have been unplanned leading to haphazard and uncoordinated expansion. The consequences include use and inundation of saline water carried by canals and rivers from the Bay of Bengal, employ traditional and not always efficient systems of farming and processing, and indiscriminate use of chemicals that are likely to be very sensitive to the overall environment. The entire process diversely affected the soil and agriculture yields, ecology, biodiversity (World Bank, 2002) and sustainability in the coastal regions of Bangladesh. In addition to the ecological costs, Barraclough and

Finger-Stich (1996) noted that modern shrimp farming also has socio-economic costs; with a cost benefit analysis study by Khor (1995) revealing that that shrimp farming might have caused more economic harm than good. The reported damage outweighed the benefits by 4 to 1 (63 billion INR1 vs. 15 billion INR per annum) in Andhra, India, for example, which included loss of mangroves, salinity intrusion and rise of unemployment.

In Bangladesh, the causes and effects of shrimp production are also varied as it in India and other countries. Shrimp farming, and the associated scale of its impact on the environment depends on a variety of interrelated factors including species farmed, the type and mode of production, scale and intensity of culture practices and physiographic location of the shrimp farm. Shrimp farming has long been causing severe threats to ecological systems of Bangladesh, such as deterioration of soil and water quality, depletion of mangrove forest, decrease of local variety of fish and shellfish, saline water intrusion in ground water, local water pollution and change of local hydrology (Kabir and Iva, 2014). Recent expansion of shrimp cultivation has caused severe depletion of forest cover in the Chakaria-Sundarbans and led to a near complete loss of mangrove forest and biodiversity of flora and fauna within (Shahid and Islam, 2003). Ground water salinization and saline water intrusion in surrounding areas have caused a serious ecological and socioeconomic damage in the coastal environment. Salinity has been dubbed as a silent poison to the coastal Bangladesh due to extensive shrimp farming (Kabir and Iva, 2014). The practices of shrimp farming have caused loss of crop production, loss many indigenous flora, drinking water and cooking fuel crisis and so on (Karim, 2003). Gradual increase in toxic elements is contaminating lower level soil and products of the soil also carry these toxic substances and have the potentiality to create health hazards. According to Alauddin and Hamid (1996), conflict associated with control of the large shrimp farms is one of the important causes responsible for social imbalance and deteriorating law and order in the coastal areas in Bangladesh. More broadly the DeWalt *et al.* (2002) summarized the following major issues as:

- Ecological consequences of conversion and changes in natural habitats such as mangroves, associated with construction of shrimp ponds and related infrastructure;
- Discharge of pond effluent leading to water pollution in farming and coastal areas;
- Seepage and discharge of saline pond water that may cause salinity changes in ground water and surrounding agricultural land.
- Use of fishmeal and fish oil in shrimp diets.
- Improper use of chemicals raising health and environmental concerns;
- Spread of shrimp diseases;
- Transboundary movements concerning the spread of genetic materials, exotic species and diseases;
- Biodiversity issues primarily arising from the collection of wild shrimp/prawn seed.

In Bangladesh, the previous commercial nature of shrimp farming has slowly been turning into smallholder-type production of shrimp; and freshwater prawn farming in rice fields during the rainy season is spreading over increasingly large inland areas of the country. Despite having very good climatic condition for shrimp farming, production efficiencies are low due to high post-larvae (PL) mortality, poor management techniques and poor farm management practices are considered responsible for lower shrimp production (Nuruzzaman *et al*., 2001; Huntington, 2003), a lack of extension services and poor infrastructure in coastal areas (Nuruzzaman, 2006). Development of shrimp aquaculture in Bangladesh has therefore been questionable and generated considerable national and international debate in recent years on its environmental and social costs and benefits. Among the substantial environmental and social problems in Bangladesh specifically are water pollution; salinization of drinking water wells and paddy fields; destruction of fry of wild fish and crustacean species; various social conflicts related to land conversion and, critically, the conversion of mangroves to shrimp farms; reduced agricultural production due to the reduction of agricultural land and soil fertility, decrease of cattle production as a result of a decline in grazing land, human health hazards and diseases and reduction in mangrove forest (UNEP, 1999). Rice farming is also said to have suffered from prolonged water logging from extended shrimp seasons (Bhattacharya *et al*., 1999; FFP, 1999). Destructive methods of shrimp PL collection from the wild have also had significant impacts on coastal biodiversity (FFP, 1999; World Bank *et al*., 2002).

2.8.3 Habitat and Landscape deterioration

The introduction of shrimp farming to the Bangladesh coast has undoubtedly increased the income of the people in coastal regions, but it has also gradually changed the land use pattern of the area, from agricultural and mangrove into shrimp farms.

The loss of land previously used for agricultural crops was estimated 352 ha (0.03%) per year between 1976 and 2000 in Khulna division, rising to losses of 8

781 ha (0.66%) per annum between 2000 and 2010. Also in Khulna, the area under forest was estimated at 617 ha in 1976, and this has declined by almost 100% up to 2000 and no further changes observed between 2000 and 2010. The area under mangrove forest decreased annually by 0.36% during 2000–2010. The area under aquaculture increases during 1976 to 2010, which was almost from zero ha in 1976 and reached to 45 596 ha in 2000 and further, increased to 96 283 ha in 2010 (Hasan *et al*., 2013).

In Barisal division, the loss of agricultural cropland is estimated at 978 ha (0.12%) per year during 1976 to 2000, reducing slightly to 666 ha (0.08%) between 2000 and 2010, to give an overall loss rate of approximately 886 ha (0.10%) during the period 1976 to 2010. The area under mangrove forest decreased annually by 4.27% during 2000 to 2010. In Barisal, the area under aquaculture increased between 1976 and 2000, from almost from zero ha to 7163 ha but it declined by 195 ha in 2010.

In Chittagong division, the area under aquaculture increased from almost zero ha in 1976 to 36486 ha in 2000 and further, increased to 45073 ha by 2010. In this division, the area under mangrove forest decreased annually by 4.18% during over the period 2000 to 2010 (Hasan *et al*., 2013).

Overall during this period approximately 50% of coastal lands face different degrees of inundation, thus limiting their effective use for anything else except aquaculture, and 70% of land in the Barisal and Khulna divisions is affected by different degrees of salinity, which reduces agricultural productivity (Mia, 2004).

2.8.4 Greenhouse Gas Contribution

Shrimp farming contribute to global greenhouse gas (GHG) emissions through various processes including fishing of shrimp brood stock, farming activity, growth, processing, transportation and storage. There are many different activities in the wider value chain from farm to fork with many different energy requirements. The predominant contributor is transportation with products typically transported via freight on ships or plane, especially if they are being exported from developing countries to developed country markets (Shelton, 2014). High-value species like shrimp are more likely to be shipped via ships or airfreight, meaning their transport emissions are quite high. In addition, small low-power single engines to larger vessels to fish factory ships need to travel farther or to deeper waters and spend more time than they have in the past to catch the same amount of brood-stock shrimp.

2.8.5 Water Impacts

Good quality water is the most vital factor in shrimp farming and production of shrimp in ghers is often limited by water quality degradation and inappropriate water depth. Water quality problems are increasing in shrimp farming areas because of excessive feeding, presence of high biomass due to high stocking density and application of drugs, antibiotics and chemicals, effluents etc. Higher amounts of particulate substances also exist as suspension in the water of shrimp ponds. Poor water qualities are causing diseases, higher mortality and low production and in some locations; it has become impossible to continue shrimp farming any more, due to these poor water quality conditions. Added to this the level of soil electrical conductivity (EC) has remarkably increased to lower depth of soil of shrimp farms affecting soil productivity. Insoluble materials from food inputs in the shrimp ponds have been prevalent causing high levels of water contamination. This has been exacerbated by the current changes in shrimp gher ownership happening all over the coast with large ghers are being converted into small ghers but without any excavation or renovation of canals and sluice gates. Stagnation of saline water in the shrimp ponds allows toxic substances to settle in the *gher* soil.

2.8.6 River Impacts

Once highly abundant fish and shellfish that were present in the estuarine river systems of Bangladesh are becoming increasingly scarce. Many important, popular and common fish and shrimp species once abundantly available in the rivers throughout the year are now disappeared altogether or found only occasionally. The biodiversity of estuarine fishes in particular might have decreased considerably due to harvesting of shrimp post-larvae and the associated indiscriminate killing of hundreds of bycatch, shellfish, mollusks and other aquatic fauna. Biodiversity is also affected by heavy siltation that has occurred, which along with river erosion has resulted in ever-decreasing river water depth. Both are concerns for locals and for fishers as the catch per unit effort has been reported to be substantially decreased. The literature reviews revealed that just five years ago it was relatively easy to catch 2 to 3 kg of fish per hour with a cast net (*khepla jal*), pull net (*thela jal*) or triangular net (tinkona jal). Now a fisher is more likely to spend 3 to 4 hours to catch less than one kilogram of fish. Both full-time and part-time fishers have complained about the diminishing catch from rivers, are having problems in maintaining income and fulfilling the needs of their families, and though difficult many are nonetheless switching from fishing to other livelihood strategies.

2.8.7 Floodplain Impacts

At the Bangladesh coast, much of the floodplain land has been under polders since the 1970s, for crop farming and flood protection and can no longer be considered as natural wetland areas. Many coastal floodplains are also now converted into shrimp farms. In addition, there are large areas of both tidally inundated and freshwater wetland areas in, and out of the polder belt that are lucrative to the shrimp farming industry for a number of reasons, including land being often water-logged and not suitable for agro-farming; polders now have almost no available land for new investors; and conflict of sharing water with other shrimp and paddy farmers. Thus, in terms of potential biodiversity loss, it is this growing trend that is more concern than the historic utilization of the polder areas. This, allied with the major expansion of freshwater prawn in very low salinity areas, shows the importance of limiting aquaculture expansion to appropriate areas that do not conflict with agricultural or biodiversity conservation needs.

In Bangladesh, beels are generally open access resources used by the local communities for fishing, grazing livestock and collection of wild plants for food, fodder and medicinal purposes during times of hardship. During the shrimp farming revolution, the low-lying land in the beels were highly sought after because it was land most easily converted into rain fed shrimp farms that could retain water throughout the year. Shrimp farms in higher areas required more irrigation to ensure a year-round supply of water. Most of the seasonal and perennial beels have now been converted into shrimp farms.

Shrimp farming has had a dramatic effect on the rural landscape and with vast areas of low lying floodplain having been converted into shrimp farms, there is concern that the adverse environmental effects of shrimp farming on wetland systems are making it unsustainable. Unplanned expansion of shrimp farms has reduced the beel area and blocked fish migration routes, caused drainage problems and reduced the grazing areas to support fewer livestock.

The beels are the natural breeding grounds for native/wild fish and support a wide range of wetland flora and fauna. The expansion of shrimp farming has had a dramatic effect on the floodplain landscape; with most of the beel area and many of the khals (canals), being the "lifelines" through which fish migrate to and from Bangladesh's main river systems, are now congested with shrimp farms. The poor drainage and reduced flow has caused many khals to completely silted. This has also been made worse by the underlying deterioration in drainage caused by building of embankments and most notably the Farakka Dam. The blockage of migration routes and destruction of their natural feeding and breeding grounds has led to sharp declines in native fish populations and some species have become extinct. Islam (2001) reported decreased fish yields and diversity in four beels in Bagerhat at a time when fishing pressure also remained high.

Fishers, who would naturally use the beels are having problems accessing the beel areas due to shrimp farm owners blocking access routes through their shrimp farms. Such blocking of routes is due to concerns of shrimp theft. Despite this lack of access and the declines highlighted, many fishers have actually seen their standard of living improved since shrimp farming started in this area resulted in increased employment opportunities. Wage rises associated with the "shrimp revolution" means that traditional fishers can earn more as a daily-paid laborer on the shrimp farms than from fishing directly. That said the likely decline in fish yields from the beels remains worrying, since it is the main source of protein for the majority of people in Bangladesh.

2.8.8 Drainage Impacts

All sluice gates constructed by Bangladesh Water Development Board (BWDB) and those under the Third Fisheries Project (TFP) are now under the management of local large shrimp farm owners. Third Fisheries Project gates are technically faulty and heavy siltation has taken place at the mouth of sluice gates, creating problems with water flow through the system. One problem with lack of flows is that a shrimp pond situated in the middle of other ponds has to depend on adjacent pond owners for their water supply and will sometimes pay money for gaining access to water. Other pond owners get water only by natural seepage from adjacent ponds, limiting water depth of an individual pond, depending on depth of these adjacent ponds.

The canals and canal system inside almost all of the polders have been encroached by local power elites; or some of them have taken a lease from the government and, ultimately, have been using this as their private property (CEGIS, 2015). Shrimp farm owners in the middle of the polders therefore suffer water shortage for their shrimp culture. When the water level of the individual pond is not uniform in all areas of the farm it creates problem for the cultured shrimp, especially in the extremely hot summer months, when evaporation is high, and shrimp can become stressed leading to disease and high mortality occurs at that time.

2.9 Impacts in the Studied Area

The shrimp yield and farming area in the southwestern coastal districts of Bangladesh have been dynamically regulated over the years; the region has ideal climatic conditions and the industry has good labor costs (Avnimelech and Ritvo, 2003; Matin *et al*., 2016). Shrimp is the second largest export product in Bangladesh after ready-made garment commodities (e.g., garment products, textile items, and vegetable textiles/yarns) and has already become a multimillion-dollar industry (Taslim and Haque, 2011). Three districts, Bagerhat, Satkhira, and Khulna, along with Rampal, a subdistrict of Bagerhat, are the significant coastal shrimp-farming districts of Bangladesh, making a major contribution to the national economy over the past two decades (Islam *et al*., 2009). These three southwestern districts contributed 75% of the total shrimp industry between 2002 and 2017 (Karim *et al*., 2019).

The shrimp yield of these southwestern coastal districts has changed continuously since the commencement of profit-oriented business in 1970 (Akber *et al*., 2017). Ahmed and Diana (2015) assessed the impact of different climatic variables on shrimp farming. Ali (2006) investigated the impact of shrimp farming on rice production, aquatic habitats, and soil properties. Afroz and Alam (2013) addressed the severe impacts of uncontrolled shrimp farming. Ahmed (2013) reviewed the issues key to meeting environmental, social, and economic challenges through prawn and shrimp farming. Alam *et al*. (2007) explored the costs and returns of shrimp farming in disease-affected areas. Matin *et al*. (2016) evaluated the present shrimp-farming situation in the southwestern coastal districts.

Little research has so far quantified shrimp yield changes utilizing focused group discussions, questionnaire surveys, and informant interviews. In order to assess shrimp yield changes between 1995 and 2015 from a historical perspective, Akber *et al*. (2017) employed a systematic random sampling method and stated that the shrimp yield is declining in the selected study area. They conducted research considering only six subdistricts of the southwestern coastal districts of Bangladesh; it is controversial that this study did not address the actual differences in shrimp yield of all southwestern coastal districts.

It is worth noting that about 80–90% of livelihoods in the southwestern coastal districts of Bangladesh depend on shrimp farming. However, the shrimp-farming area at Rampal, Bagerhat district, has changed a great deal over the past two decades along with the shrimp yield, as evidenced by government-published Fisheries Resource Survey System (FRSS) reports, newspaper articles, and so on (FRSS, Vol.21-34, 2003-2017). According to the FRSS data and existing research, shrimp production and the shrimp-farming area of Bagerhat district have been declining compared to Satkhira and Khulna districts in recent years (Mitro *et al*., 2014), the cause of which is uncertain and politically contentious. Akber et al. (2017) stated that the outbreak of disease at shrimp farms, low shrimp prices, and high labor costs accounted for the decline in shrimp-farming area and yield. Ali et al. (2006) affirmed that long-term environmental consequences such as increased salinity and a loss of biodiversity were equally responsible for the decline in shrimp yield and farming area in the southwestern coastal districts of Bangladesh. Ahmed and Diana (2015) stated that climatic variables such as cyclones, coastal flooding, drought, sea-level rise, and sea surface temperature have severe negative impacts on the production and growth of shrimp. Apart from the above factors, various researchers, local people, and shrimp farmers have pointed out that the 1320 MW coal-fired thermal power plant in Rampal appears to be a primary cause of the declining shrimp-farming area and yield since 2013.

On 2 January 2012, two years before the Environmental Impact Assessment (EIA) was approved, the Bangladeshi government handed over 1834 acres of land in Rampal to the Bangladesh Power Development Board (BPDB) in order to boost the power production of the country. Only 86 acres of this procurement land was state-owned; the rest was privately inherited shrimp farming and agricultural land (SAHR, 2015). Since construction work on the Rampal thermal power plant began in April 2017, it has led to the destruction of livelihood options (e.g., shrimp farming and agriculture) for local communities (Natalie *et al*, 2018). Landless farmers, environmentalists, nongovernment organizations, and residents of the Rampal region protested against the setting up of the power plant well before a Memorandum of Understanding (MoU) was signed between the National Thermal Power Corporation of India and BPDB on 1 November 2010 (SAHR, 2015). Organizations such as Greenpeace and Water-Aid and residents of both Bangladesh and India pointed out, that aside from the fact that many shrimp farmers and agricultural landlords had already become landless (Akash, 2013), the coal-based power plant would lead to severe public health emergencies in the surrounding area due to harmful health effects soon after the power plant became operational (Khan and Khan, 2016). The prospect of cheap power from Rampal has already attracted many industries, all of which are operating within a 10-km radius of the power plant site, which was previously used for shrimp farming (Alam, 2012). Chowdhury (2017) asserted that mitigating the shrimp farm loss would be very difficult in Rampal.

2.10 Productivity and Disease in Shrimp Farming System

Productivity of shrimp ghers (ponds) decreased heavily following the impacts of Cyclone Aila, which happened in 2009, but since then productivity has gradually increased again, at a time when the individual size of the farms has also gradually decreased, over a number of years. Overall species composition in shrimp ghers has remained similar since 2009, however, since 2003–2004, some of the farmers started mixed cultivation (shrimp along with different types of finfish) to reduce the uncertainty in income from production from the main crop – shrimp (Islam, 2003). This has been done to compensate for ever-fluctuating profit and loss from shrimp production and sales. The majority of the farmers now follow a mixed culture system, with mixture of shrimp and brackishwater finfish such as mullet (*Chelon parsia*) and barramubdi *(Lates calcarifer*) and catfish (*Mystus gulio*) (Paul, 2013; Akber *et al*., 2017). Now many of the shrimp PL providers also supply the fry and fingerlings of these brackish water fish to the shrimp farmers, which also provides additional income for the PL providers (DoF observation). Input costs of production is also gradually increasing, and in particular farmers are concerned with rising price of quality shrimp PL, feed and other input costs (Morf, 2014). Many farmers, who operate at marginal profitability, do want to stock good quality PL and to provide quality feed to the shrimp, but have been prevented from doing so because of the lack of necessary capital. Thus, although gher productivity has been increasing, overall profitability has been decreasing gradually due to higher production costs. Low profitability also results from frequent outbreaks of a number of diseases, where often the farmers lose all the shrimp in their ghers within a very short period of time.

2.10.1 Shrimp Disease Issues

Many of the diseases that occur in shrimp farms are directly caused by environmental degradation, while a number of other diseases are triggered by the stress induced by poor environmental quality. Since 1994, shrimp farming has been afflicted by outbreaks of bacterial and viral diseases, that have greatly undermined both profitability and sustainability of shrimp farming operations (FAO, 1997; Mazid and Banu, 2002; DoF, 2007). Occurrence is closely related to shrimp pond management and other parameters such as water depth, salinity, pH, water level, water quality management, soil acidity and so on. Bangladesh has experienced disease outbreak in both semi-intensive and extensive shrimp farms which were associated with physico-chemical factors such as gher pH, water temperature and dissolved oxygen concentration which fluctuate abruptly, particularly after heavy rain downpours or after long spells of drought. Under these circumstances shrimp become vulnerable to stress, leading to disease (Paez-Osuna *et al*., 2003), such as red colour, soft shell, tail rot and black gill diseases (Alam *et al*., 2007). Generally, high stocking density and excessive use of feed are the main reasons leading to degraded water quality, which contributes to stress and diseases among shrimp in semi-intensive farming systems, for example (Paez-Osuna *et al*., 2003). It is environmentally damaging when uneaten feed and other waste are discharged directly in to the culture system, which reduces the overall water quality and renders the shrimp being extremely susceptible to disease vectors present in the water. The movement of water between neighboring farms, particularly if the water is polluted and of poor quality, enables the spread of water-borne diseases from farm to farm (Paez-Osuna, 2001). Poor water quality, associated with unplanned and uncontrolled farming, has increased the incidence of disease and reduced production and productivity accordingly (Deb, 1998).

Disease outbreaks have been recognized as one of the largest problems limiting development of shrimp aquaculture in Bangladesh. Red disease and white spot disease (locally called virus) are most prevalent. Among other common diseases, black gill, tail rot, shrinkage of muscle, blue diseases, change of body color and some behavioral changes are also reported by the shrimp farmers. To complicate matters, most shrimp farmers use the term ‘virus’ to mean any diseases or health problems that cause mass mortality, irrespective of its source or diagnosis. This lack of understanding is due to a lack of training and technical knowledge, and lack of diagnosis facilities within the farmer community.

Chapter 3. Materials and Methods

3.1. Materials

3.1. 1 Study Area

The study was conducted on the shrimp producing three upazilla namely Mongla, Rampal and Fakirhat of Bagerhat district. Four shrimp cultivators from each Upazila were undertaken for experiment.

3.1.2 Study period

The survey was undertaken in 2011 and 2012 and the case studies on the selected farms were conducted in 2013 and 2014.

3.1.3 Selection of the Study Area

Shrimp culture has become a major activity in many parts of the coastal areas of Bangladesh. The culture system uses basically the same methods throughout the country and it can be loosely categorized and improved into traditional practices (Halim and Rafiqul, 2005).

The development of shrimp culture has been unplanned, resulting in diseases, deforestation, reduction of soil fertility and agricultural land and ultimately social conflicts (Rahman and Quddus, 2006). This research has selected Khulna as the study location. The soil characteristic, environment, availability of labor, market place support has made Khulna a fertile ground for shrimp cultivation.

The study was carried out in seven villages of each Upazila. These are Mithakhali, Makordon, and Joymoni of Mongla upazilla, Gourambha, Foyla and Rajnagar of Rampal upazilla and Shattola, Diapara and Tekatia of Fakirhat upazila. These areas were selected to carry out the experiment on the production of shrimp farmers. The shrimp cultivators were selected by considering farm size, farm location, culture system and water exchange facility from the aforesaid villages.

Table 3.1 Characteristics of selected farms.

Pond No.	Location	Area (Hactare)	Water Exchange Facility	Culture System
T1	Joimoni, Mongla	0.202	Yes	Improved Extensive
T2	Makordon, Mongla	0.202	Yes	Improved Extensive
T3	Mithakhali, Mongla	0.202	Yes	Improved Extensive
T4	Chandpai, Mongla	0.121	No	Extensive
T5	Rajnagar, Rampal	0.202	Yes	Improved Extensive
T6	Gauramva, Rampal	0.202	Yes	Improved Extensive
T7	Jhanjhania, Rampal	0.202	Yes	Improved Extensive
T8	Foyla, Rampal	0.121	No	Extensive
T9	Tekatia, Fakirhat	0.202	Yes	Improved Extensive
T10	Shattola, Fakirhat	0.202	Yes	Improved Extensive
T11	Diapara, Fakirhat	0.202	Yes	Improved Extensive
T12	Bighay, Fakirhat	0.121	No	Extensive

3.2. Methodology

This chapter illustrates sequential steps of research methodology. The details of data collection procedure and analysis approach are presented in this chapter. Data was collected by primary and secondary method. Primary data was collected by FGD (Focus Group Discussion), questionnaire survey, GPS (Global Positioning System) survey and Case study. Secondary data was collected from various offices and NGOs. At first shrimp farms were categorized according to their size and then samples were collected randomly from each category. Farm owners identified the factors which are responsible for location. Finally, an analysis has been done to identify the gap between traditional practice and national and international policies.

3.2.1. Conceptualization

Shrimp cultivation started as a traditional practice in the coastal part of Bangladesh. The cultivation depends on the availability of saline water. At the initial days of farming, there was no guidance from the government regarding the location of farms, no restriction on conversion of land to shrimp cultivation. Individual entrepreneurs started the business with personal investment. Huge profit in this sector encouraged large scale investment. Finally the shrimp cultivators started to occupy agricultural land and they excavated canal to bring salt water to their farm site. The widespread encroachment of agricultural land and associated environmental and social issues emerged as a concern and regulatory measures became necessary to guide and control shrimp cultivation in Bangladesh.

A set of national and international policies have been developed to guide the shrimp cultivation for considering its location, size and other issues. As mentioned earlier, the expansion of shrimp cultivation in Bangladesh is extensively fast. A number of research works has identified the adverse impact of shrimp cultivation from environmental and social perspectives (Manju, 1996). In such a context, it is important to identify the factors influence the production of tiger shrimp in the study area.

3.2.2 Secondary Data Collection

List of farms was collected from different fisheries offices. Policies and standard of International Principles 2006, Government policies such as the Fish Act (1950), The Shrimp Mohal Management Policy (1992), The Tiger Shrimp Cultivation and Pond Regulation Policy for Bagerhat District (1993), The Shrimp Cultivation Tax Act (1992) and The National Fish Policy, Documents such as Bangladesh Environment Conservation Act (1995), The National Environment Management Action Plan (NEMAP), The National Conservation Strategy, were collected from different secondary sources.

3.2.3 Primary Data Collection

In this study primary data were collected by following procedure.

3.2.3.1 Reconnaissance Survey

Reconnaissance survey was conducted at first phase of data collection. This survey was conducted to get a clear overview of the study area. The survey was conducted for one week in November, 2012. Through this survey, a general idea was developed on traditional technology, locational importance, the expansion pattern, some root causes of shrimp cultivation, environmental degradation, the social violence, involvement of government agencies etc.

3.2.3.2FGD (Focus Group Discussion)

The influencing factors have been identified by eight FGD (Focus group Discussion) at the different places in the study area. Every FGD held on a group of five to seven persons. Eleven factors came from FGD (Focus group Discussion).

3.2.3.3Questionnaire Survey

The survey was conducted through a structured questionnaire. After reconnaissance survey in the study area, based on the collected information a well-defined structured questionnaire was prepared for the household survey of the farm owners. A questionnaire was prepared for the survey of farm owner of the study areas. The survey was conducted during the month of February, 2013). The questionnaire survey was conducted on the predetermined sample size.

The collected data were also compared with other information received from UFO, DFO, BFDC, NGO's, local leaders and other owners. The selected parameters were as follows:

- family size, education and culture related information;
- socio-economic and demographic characteristics of the fishermen;
- Fish marketing, yearly income, investment, and profit;
- identification of the occupation of the fishermen;
- various assets including agricultural land, livestock, poultry and fishing;
- availability and utilization of credit and
- health and sanitation;

3.2.4 Sampling Technique and Sample Size Determination

Farms were taken as the sampling unit and farm owners are the target respondents. Stratified random sampling technique was used for the research. Farms were stratified on the basis of their size (0.1- 0.25-Hectare, 0.26-0.50Hectare, 0.51-1.0 Hectare and above 1.0 Hectare) and samples were collected proportionally from each category. The sample has been presented in the following table 3.2

3.2.5 Case Study

Several case studies have been conducted to know the existing situation of shrimp cultivators and affected people. The case study has conducted on three particular locations on first week of September 2012. All farm owners are local. Farm owners stocked too much and production failed due to unexpected slow growth rate. Some farmers used to stock shrimp PL in fresh water, it was all right for juvenile stage but after that growth stunned. Some farmers stocked PL of tiger shrimp and PL of fresh water giant prawn and also stocked 5/6 species of fin fishes and harvest a healthy production.

3.2.6. Statistical interpretation

Standard statistical tools been used for analysing the data. The farm production data were tested with one way Analysis of Variance (ANOVA) and paired t-tests. The level of significance was .95%. SYSTAT 13.2 or web based software used for the purpose.

Chapter 4. Results and Discussion

i. Survey on the shrimp culture pracices

A survey has been done among 450 Shrimp farmers from Fakirhat, Mongla & Rampal Upazila about their shrimp cultivation. It was done in April to September, 2011.

The flowing evidences been found.

According to that survey the pattern of culture is more or less same to all farmers.

- Farm Preparation: 30% Farmers don't prepare farms,70% farmers prepare but not in proper way.
- Entrance of water: 75% Farms are filled by water all the year round & the rest allow to enter water through nearby river, canal.
- Some farmers are entirely dependent on the next farmers to allow water in their farms.
- Stocking: No one maintain proper stocking ratio. Stocking usually started February/March depending on availability of PL.
- All go for continuous stocking at the interval of 14 or 28 days.
- Farmers stocked both natural & hatchery Produced PL. But Natural PL are preferred by all farmers.
- Species Combination: Early season farmers stock PL of shrimp.
- In May/June they start stocking Pl of Golda. Sometime they stocked PL of Horina.
- From end of May they start to stock fin fishes like, Tilapia, Rohu, Mrigel, Nilotica, Persia. Beside this species some wild species normally exist in the farms like, Vetki, Tengra, Corsola, Bele etc.
- Some farmers put cow dung & oil cake in the farm's bottom in derelict season, plough the land & allow the farm's bottom into the sunlight.

- Then enter water & wait for growing of special type of vegetation & then they release PL.
- 46 % Farmers apply fertilizers for plankton production.
- 70% farms haven't water exchanging system and no dewatering system.
- They can't dry their farms & can't allow sunshine to farm's bottom during non farm season.
- Feeding: Some opined the high cost of feed. However, 90% apply food but not in proper way.Most of them don't use any branded feed. They just throw some rice bran, cow dung, snail's meat, wheat, oil cake without maintaining the proper protein, carbohydrate, fat, mineral ratio.
- Harvesting: Farmers start harvesting after 2/2.5 months of stocking when shrimps become minimum marketable size. Most of the farmers start early harvesting due to disease outbreak. Harvesting is done in every 14 days based on Lunar Action.
- Simultaneously restocking is done after every harvest except final harvest.
- Problems identified after the basline survey: Disease Outbreak, Sudden mortality of shrimps, High price of PL, Low Price of harvested shrimps, Hatchery Produced PL don't grow properly, Lack of dewatering system, Weak water entrance system, High labor cost, Salinity fluctuation problem.

ii. Study on the farming system

In this study three shrimp farming upzilla viz. Mongla, Rampal and Fakirhat with four shrimp farms from each upazila were studied. Two production seasons of 2013 and 2014 were observed.

A. <u>Shrimp farms at Mongla Upazilla</u>

There were four shrimp farms selected from Mongla Upazilla, they are Joimoni, Makordon, Mithakhali and Chandpai.

4.1. Joimoni Shrimp Farm, Mongla

A farm of 50 decimals (0.202 Ha) was taken from Joimoni, Mongla, beside a canal. There were water exchange facilities. The gher was improved extensive culture system for shrimp. The culture period was February to November, 2013 and 2014. The data are represented in Table 4.1.

4.1.1.The production cycle of Joimoni, Mongla in 2013

Farm preparation was done by using lime after the Urea and TSP was applied but not in standard ratio. In the mid-February, 2013 farm owner started stocking 3000 PL of Bagda chingri (*P. monodon*). After 14 days stocked with additional 3,000 Bagda *(Penaeus monodon)* PL. In mid-March another batch of 2,000 PL were stocked. At the end of March 1,500 PL and in mid of April 1,500 PL of Bagda (*Penaeus monodon*) were introduced. So in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 11,000 in 0.202 hectare water body in nine month of culture. First two batches PL was collected from natural source and other batches were from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 55-60 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 10,000 PL of Horina (*Metapepaeus monoceros*) chingri and 1500 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn’t apply feed regularly, just some boiled broken rice and boiled lentil when available. No branded feed was used. By June all Bagda

(*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 4,000 PL of Golda (Macrobrachium rosenbergii) chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 350 pieces of Rui (*Labeo rohita*) of average weight 100 g, 250 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,500 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided for Golda (*Macrobrachium rosenbergii*) and fin fishes. Apple Snail meat, boiled broken rice and lentil were applied. Feed was applied two times daily at evening and at 10 pm. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in case of Bagda (*Penaeus monodon*) and finally 143 kg was harvested. Per hector production was found to be 0.706 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 83 Kg and per hector production was 0.410 MT. Horina (*Metapepaeus monoceros*) was harvested in total 32 Kg and per hector production was 0.158 MT. Rui (*Labeo rohita*) was harvested 186 Kg and per hector production was 0.918 MT. Karpu (*Cyprinus carpio*) was harvested 178 Kg and per hector production was 0.879 MT. Persey (*Mugil persia*) was harvested 31 Kg and per hector production was 0.153 MT. Nile Tilapia (*Oreochromis niloticus*) was harvested 397 Kg and per hector production was 1.961MT. Some other species like Chaka chingri (*Feneropenaeus indicus*), Vetki (*Lates calcarifer*), Nona-tangra (*Mystus gulio*) and some other species of fishes also exist in the farm. Total production of other species was 26 Kg and per hector production was 0.128 MT.
The water quality parameters were as follows:

Temperature range: 13.5-38°C; Salinity range: 0-16; pH range: 6.8-7.6; DO range: 4.10-5.30. These were indicating a favourable quality of water for aquaculture.

Table 4.1. The production of fishes in Joimoni, Mongla fish farm in February to November 2013 & 2014

Name of Species	**Number of PL/fries Stocked**	**Stocking Number/Ha**	**Stocking Frequency**	**2013 Total Production (MT)**	**2013 Unit Production (MT/ Ha)**	**2014 Total Production (MT)**	**2014 Unit Production (MT/ Ha)**
Bagda (*Penaeus monodon*)	11000	54340	5	0.143	0.706	0.132	0.652
Golda (*Macrobrachium rosenbergii*)	4000	19760	1	0.083	0.410	0.076	0.375
Horina (*Metapepaeus monoceros*)	10000	49400	1	0.032	0.158	0.029	0.143
Rui (*Labeo rohita*)	350	1729	1	0.186	0.918	0.185	0.913
Karpu (*Cyprinus carpio*)	250	1235	1	0.178	0.879	0.181	0.894
Persey (*Mugil persia*)	1500	7410	1	0.031	0.153	0.033	0.163
Nile tilapia (*Oreochromis niloticus*)	1500	7410	1	0.397	1.961	0.409	2.020
Other mix fishes	Not stocked but naturally existed in the farm.			0.026	0.128	0.023	0.113

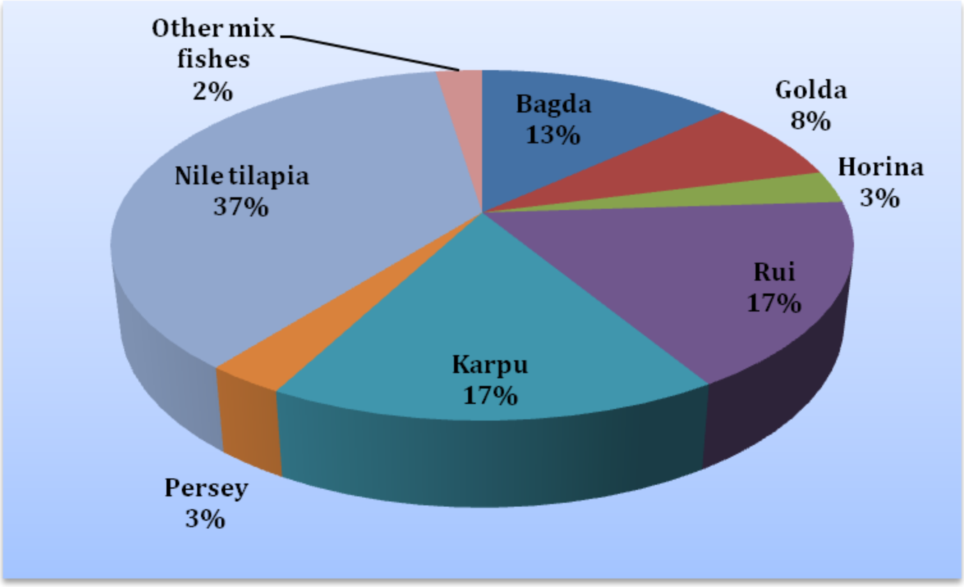

Figure 4.1. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture pond in Joimoni, Mongla fish farm in 2013

Figure 4.1. shows that the production of Bagda (*Penaeus monodon*) is 13%, Golda (*Macrobrachium rosenbergii*) 8% and Horina (*Metapepaeus monoceros*) is 3% & total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*)) is 24%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 17%, Persey (*Mugil persia*) 3%, Nile Tilapia (*Oreochromis niloticus*) 37% & mix fishes is 2% & total production of other fishes is 76% in the year 2013 in Joimoni, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.1.2. The production cycle of Joimoni, Mongla in 2014 (Table. 4.1):

The 50 Decimals (0.202 Ha) farm at Joimoni, Mongla, operated for the period of February to November, 2014.

The farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e. overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 132 kg was harvested. Per hector production was 0.652 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 76 Kg and per hector production was

0.375 MT. Horina (*Metapepaeus monoceros*) was harvested in total 29 Kg and per hector production was 0.143 MT. Rui (*Labeo rohita*) was harvested 185 Kg and per hector production was 0.913 MT. Karpu (*Cyprinus carpio*) was harvested 181 Kg and per hector production was 0.894 MT. Persey (*Mugil persia*) was harvested 33 Kg and per hector production was 0.163 MT. Nile Tilapia (*Oreochromis niloticus*) was harvested 409 Kg and per hector production was 2.020MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus gulio*) and some other species of fishes also exist in the farm. Total production of other species was 23 Kg and per hector production was 0.113 MT.

Figure 4.2 shows that the production of Bagda (*Penaeus monodon*) is 13%, Golda (*Macrobrachium rosenbergii*) 7% and Horina (*Metapepaeus monoceros*) is 3% & total production of Chingri (Bagda (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 23%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 17%, Persey (*Mugil persia*) 3%, Nile

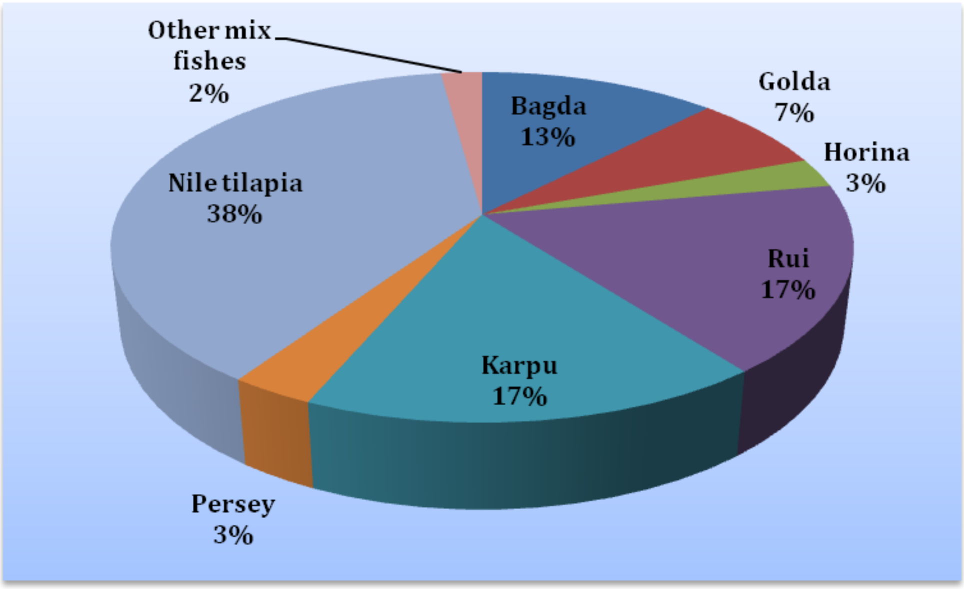

Figure 4.2. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture pond in Joimoni, Mongla fish farm in 2014

tilapia (*Oreochromis niloticus*) 38% & mix fishes is 2% & total production of other fishes is 77% in the year 2014 in Joimoni, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

The water quality parameters were as follows.

Temperature range: 14-36°C; Salinity range: 0-17; pH range: 6.5-7.5; DO range: 4.4-5.5. The parameters were of suitable for coastal aquaculture.

4.1.3. Comparison of production for year 2013 and 2014 in Joimoni, Mongla fish farm

Figure 4.3.shows that the production of Bagda (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is better in the year 2013 than 2014 & other fishes is better in the year 2014 than 2013 in Joimoni, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

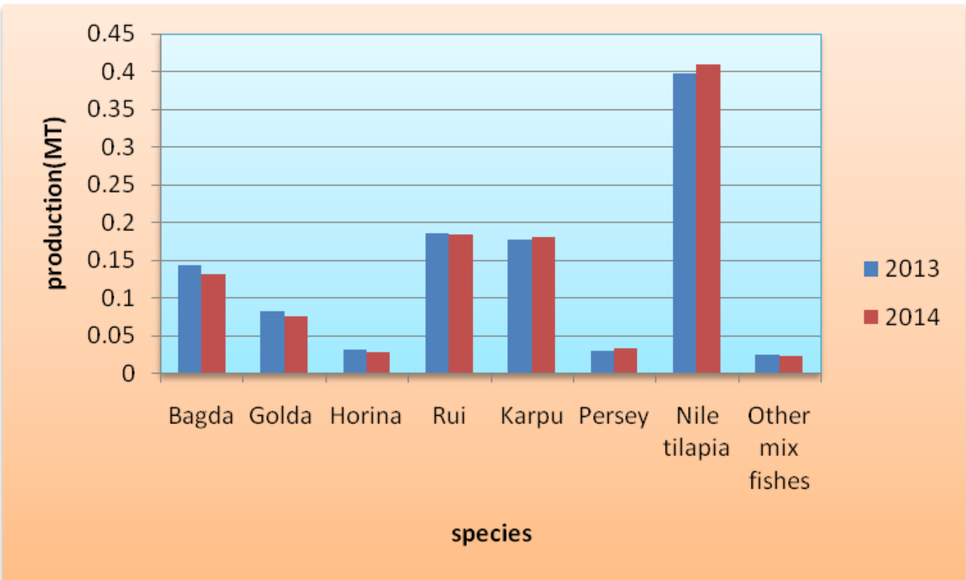

Figure 4.3. The production of Bagda (*Penaeus monodon*) and other fishes in Joimoni, Mongla in the improved extensive culture system in 2013 & 2014

However, the Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice was very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. To mitigate the loss of this mortality farmers stock fin fishes of different types.

4.1.4. Statistical comparison of production for the year 2013 and 2014 in Joimoni, Mongla fish farm.

Production data of 2013 and 2014 were compared with paired t-test. The results showed that the pond fish production of 2013 (M = 0.13450 Mt, SD = 0.125) and 2014 (M = 0.13350 Mt, SD = 0.129) was not significantly different ($t(7) = 0.407$, $p =$ .696).

4.2. The Makordon shrimp farm, Mongla

A farm of 50 decimals was taken from Makordon, Mongla, where two production seasons were observed in 2013 and 2014. The data are represented in Table 4.2.

4.2.1. The production cycle of Makordon, Mongla in 2013

The farm was stagnant one and situated in the middle position of a lot of farms and having no water exchanging facility. Farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. In the mid-February, 2013 farm owner started stocking 3000 PL of Bagda (*Penaeus monodon*) chingri (*P. monodon*). After 14 days he stocked additional 3,000 Bagda (*Penaeus monodon*) PL. In mid-March another batch of 2,000 PL were stocked. At the end of March 1,500 PL and in mid of April 1,500 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 11,000 in 0.202-hectare water body in nine months of culture. First two batches PL was collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 55-60 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 10,000 PL of Horina chingri (*Metapenaeus monoceros*) and 1500 pieces of Parsey (*Mugil persia*) were stocked.

For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed regularly, just threw some boiled broken rice and boiled lentil. No branded feed was used. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 4,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 350 pieces of Rui (*Labeo rohita*) of average weight 100 g, 250 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,500 pieces of Nile Tilapia (*Oreochromis niloticus*) were stocked. Feed was provided for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied. Feed was applied two times daily at evening and at 10 pm. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion. Overall management system like farm preparation, pre stocking and post stocking management was same as Joimoni farm. Same management was maintained to observe the difference of production of two production years in two farms with or without having water exchanging facility.

Mortality happened in case of Bagda (*Penaeus monodon*) and finally 137 kg was harvested. Per hector production was 0.676 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 71 Kg and per hector production was 0.350 MT. Horina (*Metapepaeus monoceros*) was harvested in total 28 Kg and per hector production was 0.138 MT. Rui (*Labeo rohita*) was harvested 176 Kg and per hector production was 0.869 MT. Karpu (*Cyprinus carpio*) was harvested 172 Kg and per hector production was 0.849MT. Persey (*Mugil persia*) was harvested 32 Kgs and per hector production was 0.158 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 386 Kg and per hector production was 1.906 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 25 Kg and per hector production was 0.123 MT.

Table 4.2. The production of fishes in Makordon, Mongla fish farm in February to November 2013 & 2014

Name of Species	**Number of PL/fries Stocked**	**Stocking Number/ Ha**	**Stocking Frequency**	**2013 Total Production (MT)**	**2013 Unit Production (MT/ Ha)**	**2014 Total Production (MT)**	**2014 Unit Production (MT/ Ha)**
Bagda (*Penaeus monodon*)	11000	54340	5	0.137	0.676	0.127	0.627
Golda (*Macrobrachium rosenbergii*)	4000	19760	1	0.071	0.350	0.073	0.360
Horina (*Metapepaeus monoceros*)	10000	49400	1	0.028	0.138	0.063	0.311
Rui (*Labeo rohita*)	350	1729	1	0.176	0.869	0.197	0.973
Karpu (*Cyprinus carpio*)	250	1235	1	0.172	0.849	0.191	0.943
Persey (*Mugil persia*)	1500	7410	1	0.032	0.158	0.037	0.182
Nile tilapia (*Oreochromis niloticus*)	1500	7410	1	0.386	1.906	0.326	1.610
Other mix fishes	Not stocked but naturally existed in the farm.			0.025	0.123	0.026	0.128

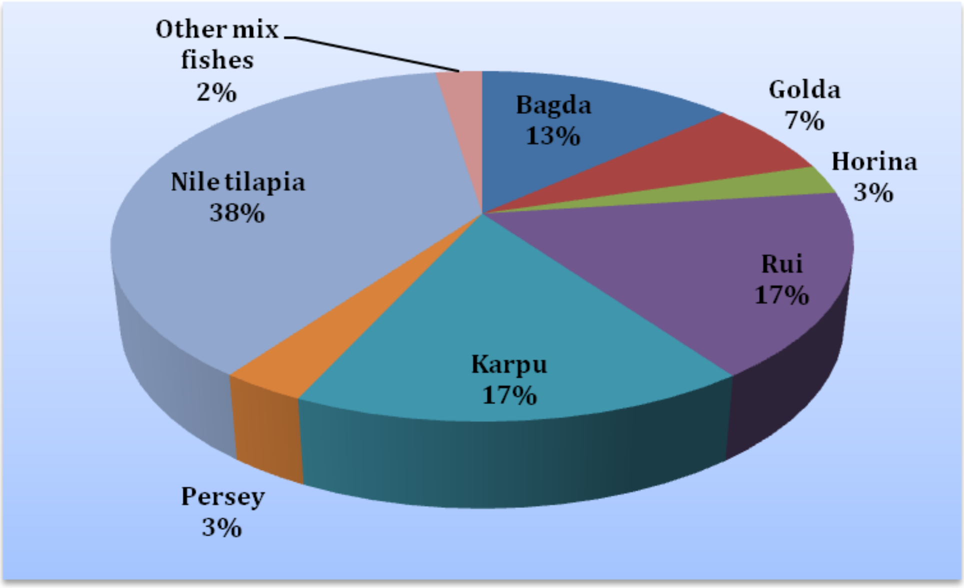

Figure 4.4. The production percentage of Bagda (*Penaeus monodon*) and other fishes in improved extensive culture systemin Makordon, Mongla fish farm in 2013

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 13%, Golda (*Macrobrachium rosenbergii*) 7% and Horina (*Metapepaeus monoceros*) is 3% & total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 23%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 17%, Persey (*Mugil persia*) 3%, Nile Tilapia (*Oreochromis niloticus*) 38% & mix fishes is 2% & total production of other fishes is 77% in the year 2013 in Makordon, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.2.2. The production cycle of Makordon, Mongla in 2014

The culture period at Makordon pond at Mongla was February to November, 2014. There were water exchange facilities. The gher was improved extensive culture system for shrimp.

For farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 127 kg was harvested. Per hector production was 0.627 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 73 Kg and per hector production was 0.360 MT. Horina (*Metapepaeus monoceros*) was harvested in total 63 Kg and per hector production was 0.311 MT. Rui (Labeo rohita) was harvested 197 Kg and per hector production was 0.973 MT. Karpu (*Cyprinus carpio*) was harvested 191 Kg and per hector production was 0.943 MT. Persey (*Mugil persia*) was harvested 37 Kg and per hector production was 0.182 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 326 Kg and per hector production was 1.610 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 26 Kg and per hector production was 0.128 MT.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (Penaeus monodon) and Golda (Macrobrachium rosenbergii) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

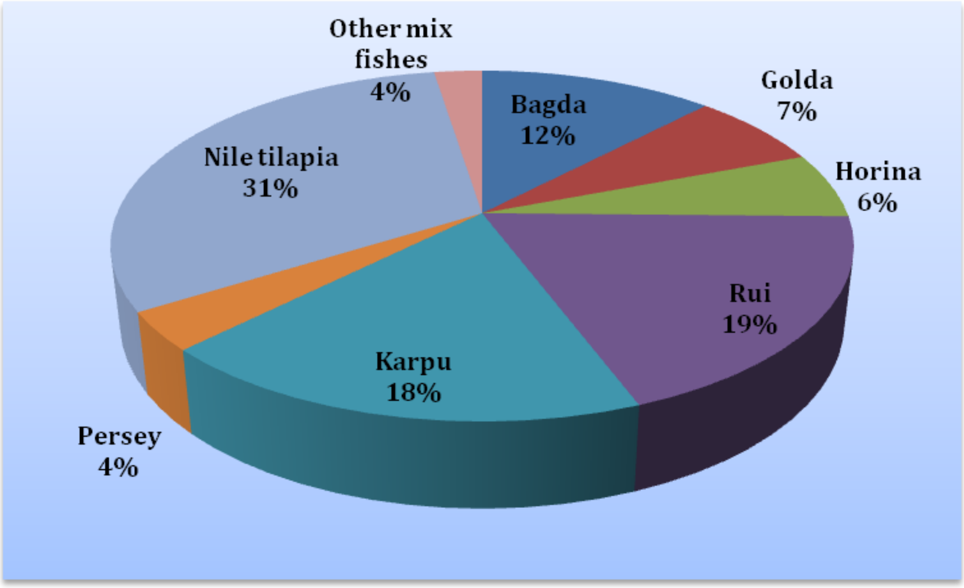

Figure 4.5. The production percentage of Bagda (*Penaeus monodon*) and other fishes Improved extensive culture in Makordon, Mongla fish farm in 2014

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 12%, Golda (*Macrobrachium rosenbergii*) 7% and Horina (*Metapepaeus monoceros*) is 6% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*)) is 25%. Other fishes like Rui (*Labeo rohita*) is 19%, Karpu (*Cyprinus carpio*) 18%, Persey (*Mugil persia*) 4%, Nile Tilapia (*Oreochromis niloticus*) 31% & mix fishes is 4% & total production of other fishes is 75% in the year 2014 in Makordon, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

The farm water quality parameters were as follows. Temperature range: 13.5-38°C; Salinity range: 0-16; pH range: 6.8-7.6; DO range: 4.10-5.30.

4.2.3. Comparisn of production cycle of Makordon, Mongla in 2013 and 2014

Figure 4.6 shows that the production of Bagda (*Penaeus monodon*) is better in the year 2013 than 2014 &Golda (*Macrobrachium rosenbergii*), Horina (*Metapepaeus monoceros*) & other fishes is better in the year 2014 than 2013 in Makordon, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

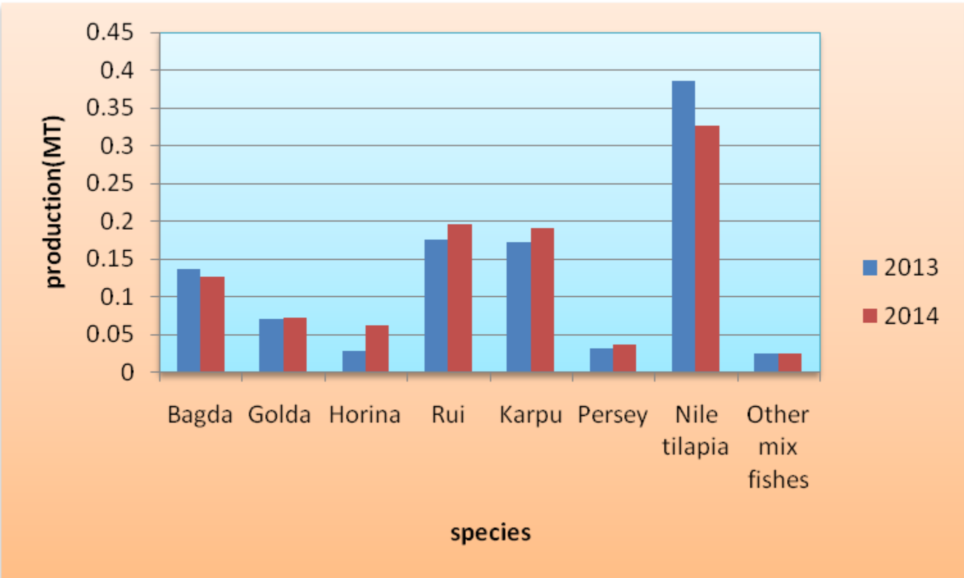

Figure 4.6. The production of Bagda (*Penaeus monodon*) and other fishes in Makordon, Mongla in the improved extensive culture system in 2013 and 2014

4.2.4. Statistical comparison of production for the year 2013 and 2014 in Makordon, Mongla fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.12838 Mt, SD = 0.122) and 2014 (M = 0.13000 Mt, SD = 0.1103) was not significantly different ($t(7) = 0.161$, $p = .877$).

4.3. Mithakhali, Mongla shrimp pond

The farm area was 30 Decimals, i.e. 0.121 Hectare, located at Mithakhali, Mongla, beside a canal. There were water exchange facilities. The gher was improved extensive culture system for shrimp. The culture period was February to November, 2013 and 2014. The data are represented in Table 4.3.

4.3.1. The production cycle of Mithakhali, Mongla in 2013

In Improved extensive culture system, scientifically all activities are not practiced. Pond preparation is not done and stocking density and species combination are not done properly. But to conduct the research a minimum farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. Stocking density and species combination was also maintained to observe the result.

In the mid-February, 2013 farm owner started stocking 1500 PL of Bagda (*Penaeus monodon*) . After 14 days he stocked additional 1,000 Bagda (*Penaeus monodon*) PL. In mid-March another batch of 1,000 PL were stocked and at the end of March 1,000 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 4,500 in 0.121 hectare water body in nine month of culture. First two batches PL were collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 60-70 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 5,000 PL of Horina chingri (*Metapenaeus monoceros*) and 1000 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed, entirely dependent on natural feed. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 2,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 200 pieces of Rui (*Labeo rohita*) of average weight 100 g, 150 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,000 pieces of Nile Tilapia (*Oreochromis niloticus*) were stocked. Feed was provided partially or very few for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied at times, not regularly and without maintaining proper proportion of ingredients and feeding time. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in every year in case of Bagda (*Penaeus monodon*) and finally 51 kg was harvested. Per hector production was 0.419 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 39 Kg and per hector production was 0.321 MT. Horina (*Metapepaeus monoceros*) was harvested in total 12 Kg and per hector production was 0.098 MT. Rui (*Labeo rohita*) was harvested 82 Kg and per hector production was 0.675 MT. Karpu (*Cyprinus carpio*) was harvested 76 Kg and per hector production was 0.625 MT. Persey (*Mugil persia*) was harvested 19 Kg and per hector production was 0.156 MT. Nile Tilapia (*Oreochromis niloticus*) was harvested 167 Kg and per hector production was 1.374 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus gulio*) and some other species of fishes also exist in the farm. Total production of other species was 16 Kg and per hector production was 0.131 MT.

The farm was situated beside a canal and water was exchanged during culture period. Extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 11%, Golda (*Macrobrachium rosenbergii*) 8% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda (*Penaeus monodon*) , Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 22%. Other fishes like Rui (Labeo rohita) is 18%, Karpu (*Cyprinus carpio*) 16%, Persey (*Mugil persia*) 4%, Nile tilapia (*Oreochromis niloticus*) 36% & mix fishes is 4% &total production of other fishes is 78% in the year 2013 in Mithakhali , Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

The water quality parameters were as follows.

Temperature range: 13.5-38°C; Salinity range: 0-16; pH range: 6.8-7.6; DO range: 4.10-5.30

4.3.2. The production cycle of Mithakhali**, Mongla in 2014 (Table. 4.3):**

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 59 kg was harvested. Per hector production was 0.485 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 36 Kg and per hector production was 0.296 MT. Horina (*Metapepaeus monoceros*) was harvested in total 13 Kg and per hector production was 0.107 MT. Rui (*Labeo rohita*) was harvested 84 Kg and per hector production was 0.691 MT. Karpu (*Cyprinus carpio*) was harvested 78 Kg and per hector production was 0.642 MT. Persey (*Mugil persia*) was harvested 20 Kgs and per hector production was 0.164 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 173 Kg and per hector production was 1.424 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 15 Kg and per hector production was 0.123 MT.

The farm was situated beside a canal and water was exchanged during culture period. Extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

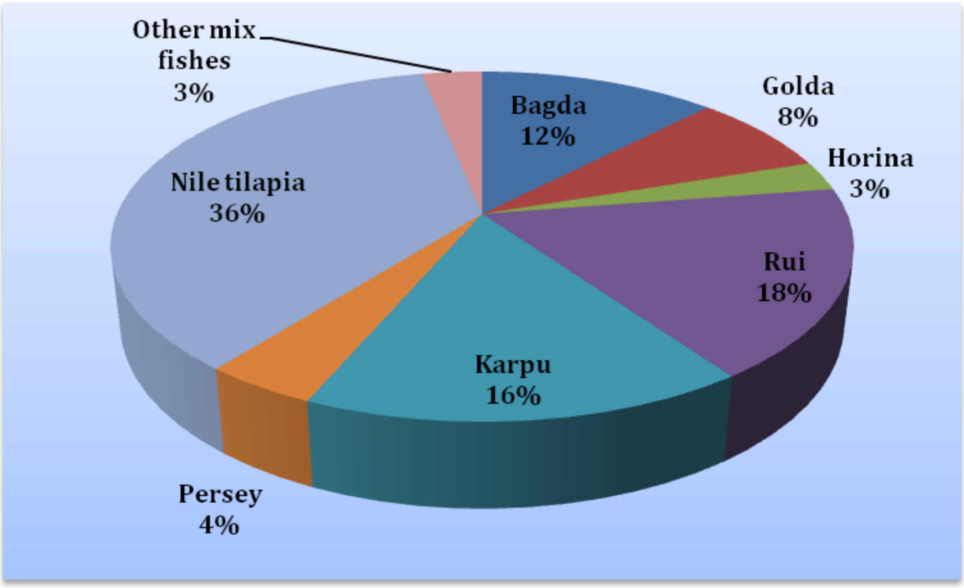

Figure 4.7. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture system in Mithakhali , Mongla fish farm in 2014

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 12%, Golda (*Macrobrachium rosenbergii*) 8% and Horina (*Metapepaeus monoceros*) is 3% and total production of Chingri (Bagda (*Penaeus monodon*),

Table 4.3. The production of fishes in Mithakhali, Mongla fish farm in February to November 2013 & 2014

Name of Species	Number of PL/fries Stocked	Stocking Number/Ha	Stocking Frequency	2013 Total Production (MT)	2013 Unit Production (MT/ Ha)	2014 Total Production (MT)	2014 Unit Production (MT/ Ha)
Bagda (*Penaeus monodon*)	4500	37050	4	0.051	0.419	0.059	0.485
Golda (*Macrobrachium rosenbergii*)	2000	16467	1	0.039	0.321	0.036	0.296
Horina (*Metapepaeus monoceros*)	5000	41167	1	0.012	0.098	0.013	0.107
Rui (*Labeo rohita*)	200	1647	1	0.082	0.675	0.084	0.691
Karpu (*Cyprinus carpio*)	150	1235	1	0.076	0.625	0.078	0.642
Persey (*Mugil persia*)	1000	8233	1	0.019	0.156	0.020	0.164
Nile tilapia (*Oreochromis niloticus*)	1000	8233	1	0.167	1.374	0.173	1.424
Other mix fishes	Not stocked but naturally existed in the farm.			0.016	0.131	0.015	0.123

Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 23%. Other fishes like Rui (*Labeo rohita*) is 18%, Karpu (*Cyprinus carpio*) 16%, Persey (*Mugil persia*) 4%, Nile Tilapia (*Oreochromis niloticus*) 36% & mix fishes is 3% & total production of other fishes is 77% in the year 2014 in Mithakhali, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.3.3. Comparison of the production cycle of Mithakhali, Mongla in 2013 and 2014

The comparison is shown in Figure 4.9.

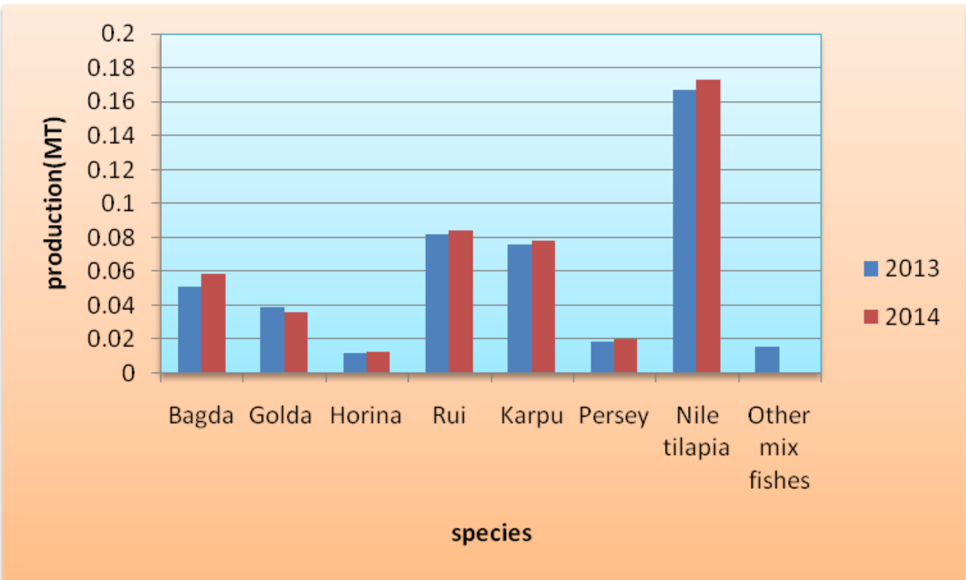

Figure 4.8. The production of Bagda (*Penaeus monodon*) and other fishes in Mithakhali, Mongla in the Improved extensive culture system in 2013 and 2014

Figure 4.9. shows that the production of Golda (*Macrobrachium rosenbergii*) is better in the year 2013 than 2014 & Bagda (*Penaeus monodon*), Horina (*Metapepaeus monoceros*) & other fishes is better in the year 2014 than 2013 in Mithakhali,Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.3.4. Statistical comparison of production for the year 2013 and 2014 in Mithakhali, Mongla fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (*M* = 0.05775 Mt, *SD* = 0.052) and 2014 (*M* = 0.05975 Mt, *SD* = 0.054) was significantly different ($t(7) = 1.595$, $p = .155$).

4.4. Chandpai, **Mongla shrimp pond**

The farm area was 30 Decimals, i.e. 0.121 Hectare, located at Chandpai, Mongla. There were no water exchange facilities/stagnant waterbody. The gher was extensive culture system for shrimp. The culture period was February to November in 2013 and 2014. The data are represented in Table 4.4.

4.4.1. The production cycle of Chandpai, Mongla in 2013

In extensive culture system, scientifically all activities are not practiced. Pond preparation is not done and stocking density and species combination are not done properly. But to conduct the research a minimum farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. Stocking density and species combination was also maintained to observe the result.

In the mid-February, 2013 farm owner started stocking 1500 PL of Bagda (*Penaeus monodon*) chingri (*P. monodon*). After 14-days he stocked additional 1,000 Bagda (*Penaeus monodon*) PL. In mid-March another batch of 1,000 PL were stocked and at the end of March 1,000 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 4,500 in 0.121-hectare water body in nine months of culture. First two batches PL was collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 60-70 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 5,000 PL of Horina (*Metapepaeus monoceros*) chingri and 1000 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed, entirely dependent on natural feed. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 2,000 PL of Golda chingri (Macrobrachium rosenbergii) were stocked. Simultaneously some freshwater fin fishes were stocked. 200 pieces of Rui (*Labeo rohita*) of average weight 100 g, 150 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,000 pieces of Nile Tilapia (*Oreochromis niloticus*) were stocked. Feed was provided partially or very few for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied at times, not regularly and without maintaining proper proportion of ingredients and feeding time. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in every year in case of Bagda (*Penaeus monodon*) and finally 53 kg was harvested. Per hector production was 0.436 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 33 Kg and per hector production was 0.271 MT. Horina (*Metapepaeus monoceros*) was harvested in total 12 Kg and per hector production was 0.098 MT. Rui (*Labeo rohita*) was harvested 76 Kg and per hector production was 0.625 MT. Karpu (*Cyprinus carpio*) was harvested 80 Kg and per hector production was 0.658 MT. Persey (*Mugil persia*) was harvested 17 Kg and per hector production was 0.139 MT. Nile tilapia (Oreochromis niloticus) was harvested 169 Kg and per hector production was 1.391 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus gulio*) and some other species of fishes also exist in the farm. Total production of other species was 14 Kg and per hector production was 0.115 MT.

Table 4.4. The production of fishes in Chandpai, Mongla fish farm in February to November 2013 and 2014

Name of Species	Number of PL/fries Stocked	Stocking Number/Ha	Stocking Frequency	2013 Total Production (MT)	2013 Unit Production (MT/ Ha)	2014 Total Production (MT)	2014 Unit Production (MT/ Ha)
Bagda (*Penaeus monodon*)	4500	37050	4	0.053	0.436	0.051	0.419
Golda (*Macrobrachium rosenbergii*)	2000	16467	1	0.033	0.271	0.037	0.304
Horina (*Metapepaeus monoceros*)	5000	41167	1	0.012	0.098	0.011	0.090
Rui (*Labeo rohita*)	200	1647	1	0.076	0.625	0.078	0.642
Karpu (*Cyprinus carpio*)	150	1235	1	0.080	0.658	0.079	0.650
Persey (*Mugil persia*)	1000	8233	1	0.017	0.139	0.016	0.131
Nile tilapia (*Oreochromis niloticus*)	1000	8233	1	0.169	1.391	0.174	1.432
Other mix fishes	Not stocked but naturally existed in the farm.			0.014	0.115	0.016	0.131

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (Penaeus monodon) and Golda (Macrobrachium rosenbergii) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

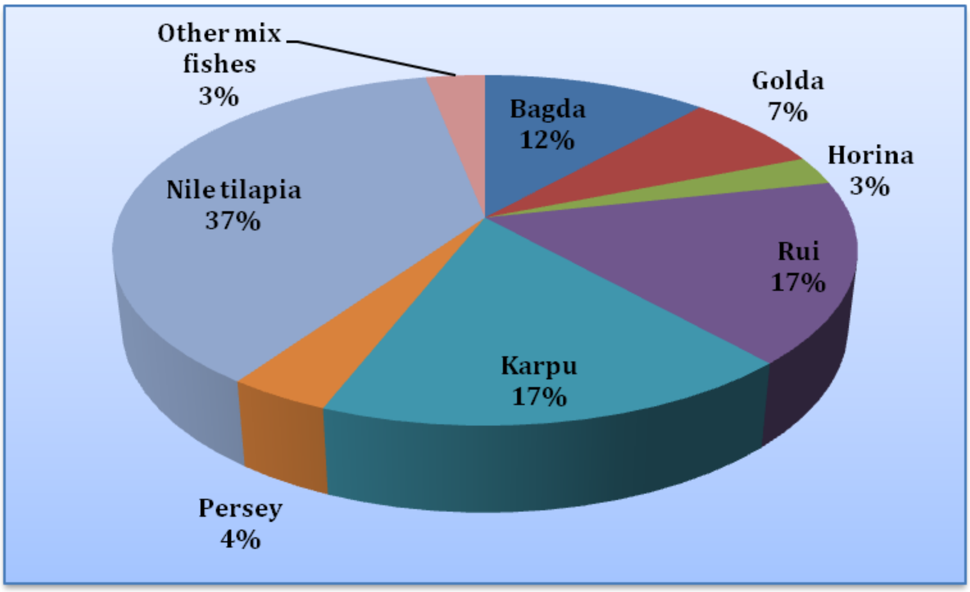

Figure 4.9. The production percentage of Bagda (*Penaeus monodon*) and other fishes in extensive culture system in Chandpai, Mongla fish farm in 2013

Figure 4.10. shows that the production of Bagda (*Penaeus monodon*) is 12%, Golda (*Macrobrachium rosenbergii*) 7% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 22%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 17%, Persey (*Mugil persia*) 4%, Nile tilapia (*Oreochromis niloticus*) 37% & mix fishes is 3% &total production of other fishes is 78% in the year 2013 in Chandpai**,** Mongla fish farm in the extensive culture system in case of farms having no water exchange facility.

4.4.2. The production cycle of Chandpai, Mongla in 2014

The farm area was 30 Decimals, i.e. 0.121 Hectare, located at Chandpai, Mongla. There were no water exchange facilities/ stagnant water body. The gher was extensive culture system for shrimp. The culture period was February to November, 2014.

The water quality parameters were as follows.

Temperature range: 13.5-38°C: Salinity range: 0-16: pH range: 6.8-7.6; DO range: 4.10-5.30

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e. overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 51 kg was harvested. Per hector production was 0.419 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 37 Kg and per hector production was 0.304 MT. Horina (*Metapepaeus monoceros*) was harvested in total 11 Kg and per hector production was 0.090 MT. Rui (*Labeo rohita*) was harvested 78 Kg and per hector production was 0.642 MT. Karpu (*Cyprinus carpio*) was harvested 79 Kg and per hector production was 0.650 MT. Persey (*Mugil persia*) was harvested 16 Kg and per hector production was 0.131 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 174 Kg and per hector production was 1.432 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus gulio*) and some other species of fishes also exist in the farm. Total production of other species was 16 Kg and per hector production was 0.131 MT.

Figure 4.11. shows that the production of Bagda (*Penaeus monodon*) is 11%, Golda (*Macrobrachium rosenbergii*) 8% and Horina (*Metapepaeus monoceros*) is 2% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*)) is 21%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 17%, Persey (*Mugil persia*) 4%, Nile tilapia (*Oreochromis niloticus*) 38% & mix fishes is 3% &total production of other fishes is 79% in the year 2014 in Chandpai**,** Mongla fish farm in the extensive culture system in case of farms having no water exchange facility.

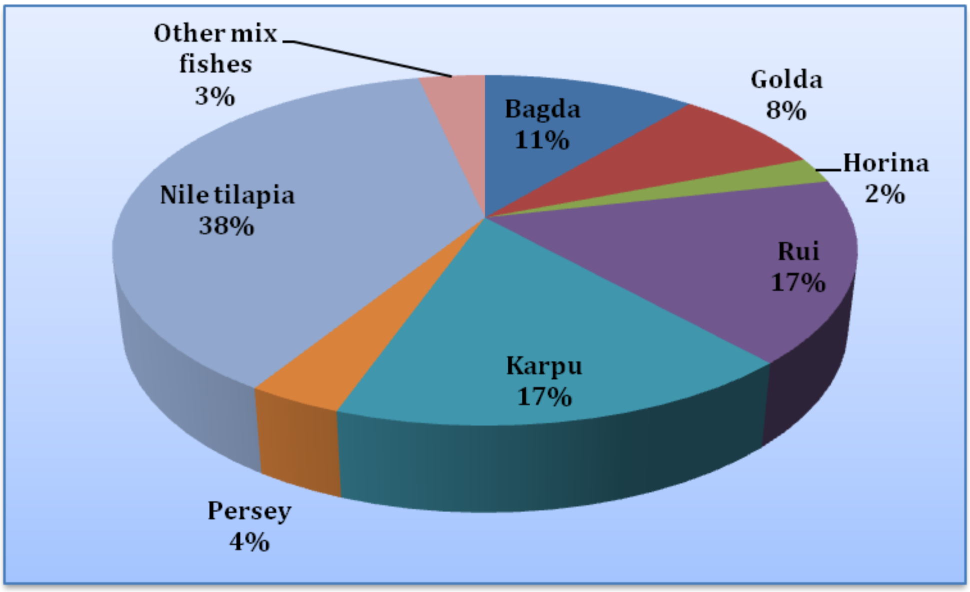

Figure 4.10. The production percentage of Bagda (*Penaeus monodon*) and other fishes in extensive culture systemin Chandpai, Mongla fish farm in 2014

4.4.3. Comparison of production for the year 2013 and 2014 in Chandpai, Mongla fish farm

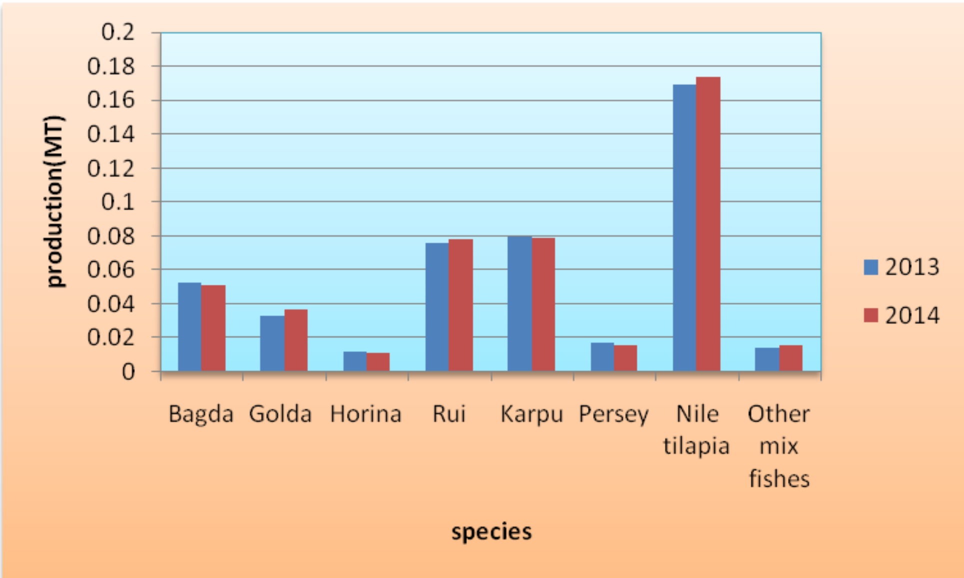

Figure 4.11. The production of Bagda (*Penaeus monodon*) and other fishes in Chandpai, Mongla in the extensive culture system in 2013 & 2014

Above Figure shows that the production of Bagda (*Penaeus monodon*), Horina (*Metapepaeus monoceros*), Rui (*Labeo rohita*), Karpu (*Cyprinus carpio*) is better in the year 2013 than 2014 & Golda (*Macrobrachium rosenbergii*), Nile tilapia (*Oreochromis niloticus*) fishes is better in the year 2014 than 2013 in Chandpai**,** Mongla fish farm in the extensive culture system in case of farms having no water exchange facility.

4.4.4. Statistical comparison of production for the year 2013 and 2014 in Chandpai, Mongla fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.05675 Mt, SD = 0.053) and 2014 (M = 0.05775 Mt, SD = 0.054) was not significantly different ($t(7)$ = 1.0801, p= .316).

B. <u>Shrimp farms at Rampal Upazilla</u>

There were four shrimp farms selected from Rampal Upazilla, they are Rajnagar, Gauromva, Jhanjhania and Foyla.

Two production seasons (2013 and 2014) were considered, of which two farms were practiced improved extensive culture system another two were undergoes extensive culture system. Between the improved extensive two one has water exchange facilities and another has none. This was done for all three upazilas. Farm size, stocking density and other management like, liming, fertilization, feeding, water quality management were all most same for each area. We carried out this to observe the production difference in various condition i.e. to identify the responsible factors for shrimp production. The data are represented in Table 4.5.

4.5.1. **Rajnagar, Rampal shrimp farm**

The farm area was 50 Decimals, i.e. 0.202 Hectare, located at Rajnagar, Rampal, beside a canal. There were water exchange facilities. The gher was improved extensive culture system for shrimp.

4.5.2. The production cycle of Rajnagar, Rampal in 2013

The culture period was February to November, 2013. The water quality parameters were as follows.

Temperature range: 13.5-38°C; Salinity range: 0-12; pH range: 6.8-7.6; DO range: 4.10-5.30. The water quality was suitable for aquaculture.

Farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. In the mid-February, 2013 farm owner started stocking 3000 PL of Bagda (*Penaeus monodon*) chingri (*P. monodon*). After 14 days he stocked additional 3,000 Bagda (*Penaeus monodon*) PL. In mid-March another batch of 2,000 PL were stocked. At the end of March 1,500 PL and in mid of April 1,500 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 11,000 in 0.202-hectare water body in nine months of culture. First two batches PL was collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 55-60 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 10,000 PL of Horina (*Metapepaeus monoceros*) chingri (*Metapenaeus monoceros*) and 1500 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed regularly, just threw some boiled broken rice and boiled lentil. No branded feed was used. By June all Bagda (Penaeus monodon) and Horina (*Metapepaeus monoceros*) were harvested and 4,000 PL of Golda (*Macrobrachium rosenbergii*) chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 350 pieces of Rui (*Labeo rohita*) of average weight 100 g, 250 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,500 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied. Feed was applied two times daily at evening and at 10 pm. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in case of Bagda (*Penaeus monodon*) and finally 139 kg was harvested. Per hector production was 0.686 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 84 Kg and per hector production was 0.414 MT. Horina (*Metapepaeus monoceros*) was harvested in total 31 Kg and per hector production was 0.153 MT. Rui (*Labeo rohita*) was harvested 199 Kg and per hector production was 0.983 MT. Karpu (*Cyprinus carpio*) was harvested 189 Kg and per hector production was 0.933 MT. Persey (*Mugil persia*) was harvested 29 Kgs and per hector production was 0.143 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 312 Kg and per hector production was 1.541MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 26 Kg and per hector production was 0.128 MT (Table 4.5).

The farm water remperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

Table 4.5. The production of fishes in Rajnagar, Rampal fish farm in February to November 2013 & 2014

Name of Species	**Number of PL/fries Stocked**	**Stocking Number/Ha**	**Stocking Frequency**	**2013 Total Production (MT)**	**2013 Unit Production (MT/ Ha)**	**2014 Total Production (MT)**	**2014 Unit Production (MT/ Ha)**
Bagda (*Penaeus monodon*)	11000	54340	5	0.139	0.686	0.141	0.696
Golda (*Macrobrachium rosenbergii*)	4000	19760	1	0.084	0.414	0.081	0.400
Horina (*Metapepaeus monoceros*)	10000	49400	1	0.031	0.153	0.032	0.158
Rui (*Labeo rohita*)	350	1729	1	0.199	0.983	0.186	0.918
Karpu (*Cyprinus carpio*)	250	1235	1	0.189	0.933	0.181	0.894
Persey (*Mugil persia*)	1500	7410	1	0.029	0.143	0.029	0.143
Nile tilapia (*Oreochromis niloticus*)	1500	7410	1	0.312	1.541	0.311	1.536
Other mix fishes	Not stocked but naturally existed in the farm.			0.026	0.128	0.027	0.133

Figure 4.13 shows that the production of Bagda (*Penaeus monodon*) is 14%, Golda (*Macrobrachium rosenbergii*) 8% and Horina (*Metapepaeus monoceros*) is 3% & total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 25%. Other fishes like Rui (*Labeo rohita*) is 20%, Karpu (*Cyprinus carpio*) 19%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 31% & mix fishes is 2% &total production of other fishes is 75% in the year 2013 in Rajnagar, Rampal fish farm in the improved extensive culture system in case of farms having water exchange facility.

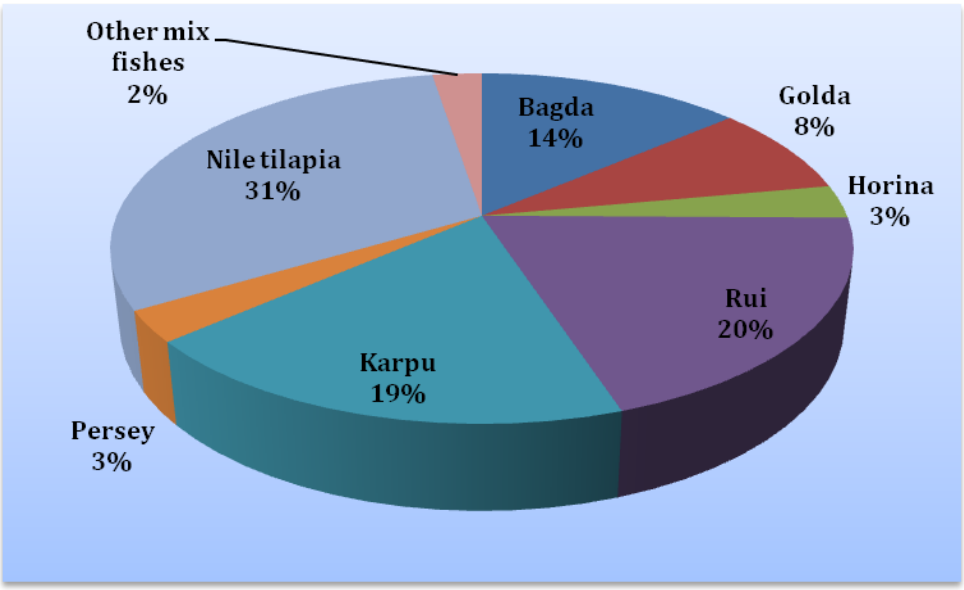

Figure 4.12. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture systemin Rajnagar, Rampal fish farm in 2013

4.5.3. The production cycle of Rajnagar, Rampal in 2014

Here the production of 2014 is described. Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 141 kg was harvested. Per hector production was 0.696 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 81 Kg and per hector production was 0.400 MT. Horina (*Metapepaeus monoceros*) was harvested in total 32 Kg and per hector production was 0.158 MT. Rui (*Labeo rohita*) was harvested 186 Kg and per hector production was 0.918 MT. Karpu (*Cyprinus carpio*) was harvested 181 Kg and per hector production was 0.894 MT. Persey (*Mugil persia*) was harvested 29 Kgs and per hector production was 0.143 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 311 Kg and per hector production was 1.536 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 27 Kg and per hector production was 0.133 MT.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (Penaeus monodon) and Golda (Macrobrachium rosenbergii) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

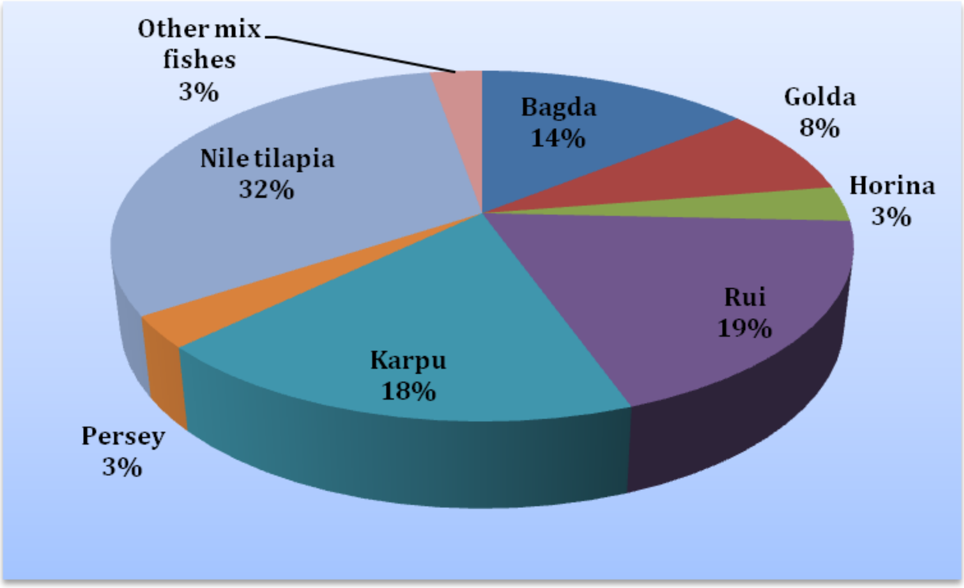

Figure 4.13. The production percentage of Bagda (*Penaeus monodon*) and other fishesin Improved extensive culture systemin Rajnagar, Rampal fish farm in 2014

Above Figure shows that the production of Bagda (Penaeus monodon) is 14%, Golda (Macrobrachium rosenbergii) 8% and Horina (Metapepaeus monoceros) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 25%. Other fishes like Rui (*Labeo rohita*) is 19%, Karpu (*Cyprinus carpio*) 18%, Persey (Mugil persia) 3%, Nile tilapia (*Oreochromis niloticus*) 32% & mix fishes is 3% &total production of other fishes is 75% in the year 2014 in Rajnagar, Rampal fish farm in the improved extensive culture system in case of farms having water exchange facility.

The water quality parameters were as follows. Temperature range: 13.5-38°C; Salinity range: 0-12; pH range: 6.8-7.6; DO range: 4.10-5.30

4.5.4. Comparison of production for the year 2013 and 2014 in Rajnagar, Rampal fish farm

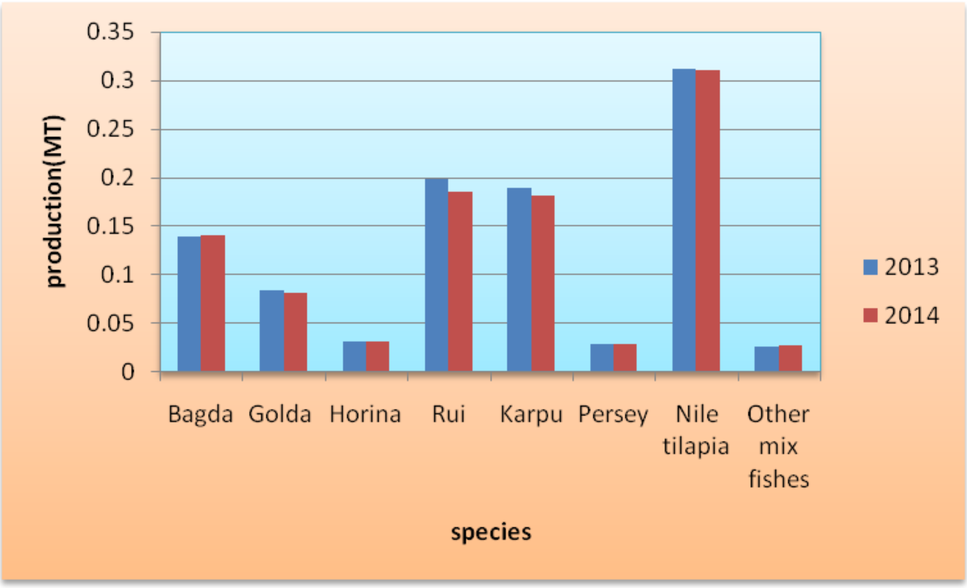

Figure 4.14. The production of Bagda (*Penaeus monodon*) and other fishes in Rajnagar, Rampal in the improved extensive culture system in 2013 & 2014

Above Figure shows that the production of Goida, Horina (*Metapepaeus monoceros*), Rui (Labeo rohita), Karpu (*Cyprinus carpio*) is better in the year 2013 than 2014 & Bagda (*Penaeus monodon*) is better in the year 2014 than 2013 in Rajnagar, Rampal fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.5.5. Statistical comparison of production for the year 2013 and 2014 in Rajnagar, Rampal fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.12613 Mt, SD = 0.103) and 2014 (M = 0.12350 Mt, SD = 0.101) was not significantly different ($t_{(7)}$ = 1.4108, p= .201).

4.6 Gauromva, Rampal shrimp pond

The farm area was 50 Decimals, i.e. 0.202 Hectare, located at Gauromva, Rampal, beside a canal. There were water exchange facilities. The gher was improved extensive culture system for shrimp. The data are provided in Table 4.6.

4.6.1. Gauromva, Rampal shrimp pond production in 2013

Farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. In the mid-February, 2013 farm owner started stocking 3000 PL of Bagda (*Penaeus monodon*) chingri (*P. monodon*). After 14 days he stocked additional 3,000 Bagda (*Penaeus monodon*) PL. In mid-March another batch of 2,000 PL were stocked. At the end of March 1,500 PL and in mid of April 1,500 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 11,000 in 0.202-hectare water body in nine months of culture. First two batches PL was collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 55-60 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 10,000 PL of Horina (*Metapepaeus monoceros*) chingri (Metapenaeus monoceros) and 1500 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed regularly, just threw some boiled broken rice and boiled lentil. No branded feed was used. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 4,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 350 pieces of Rui (*Labeo rohita*) of average weight 100 g, 250 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,500 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied. Feed was applied two times daily at evening and at 10 pm. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in case of Bagda (*Penaeus monodon*) and finally 137kg was harvested. Per hector production was 0.676 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 89 Kg and per hector production was 0.439 MT. Horina (*Metapepaeus monoceros*) was harvested in total 29 Kg and per hector production was 0.143 MT. Rui (*Labeo rohita*) was harvested 177 Kg and per hector production was 0.874 MT. Karpu (*Cyprinus carpio*) was harvested 182 Kg and per hector production was 0.899 MT. Persey (*Mugil persia*) was harvested 23 Kgs and per hector production was 0.113 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 298 Kg and per hector production was 1.472 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus gulio*) and some other species of fishes also exist in the farm. Total production of other species was 28 Kg and per hector production was 0.18 MT.

Figure 4.16 shows that the production of Bagda (*Penaeus monodon*) is 14%, Golda (*Macrobrachium rosenbergii*) 9% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 26%. Other fishes like Rui (*Labeo rohita*) is 18%, Karpu (*Cyprinus carpio*) 19%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 38% & mix fishes is 3% &total production of other fishes is 74% in the year 2013 in Gauromva,

Table 4.6. The production of fishes in Gauromva, Rampal fish farm in February to November 2013 & 2014

Name of Species	Number of PL/fries Stocked	Stocking Number/Ha	Stocking Frequency	2013 Total Production (MT)	2013 Unit Production (MT/ Ha)	2014 Total Production (MT)	2014 Unit Production (MT/ Ha)
Bagda (*Penaeus monodon*)	11000	54340	5	0.137	0.676	0.134	0.661
Golda (*Macrobrachium rosenbergii*)	4000	19760	1	0.089	0.439	0.083	0.410
Horina (*Metapepaeus monoceros*)	10000	49400	1	0.029	0.143	0.028	0.138
Rui (*Labeo rohita*)	350	1729	1	0.177	0.874	0.179	0.884
Karpu (*Cyprinus carpio*)	250	1235	1	0.182	0.899	0.176	0.869
Persey (*Mugil persia*)	1500	7410	1	0.023	0.113	0.028	0.138
Nile tilapia (*Oreochromis niloticus*)	1500	7410	1	0.298	1.472	0.294	1.452
Other mix fishes	Not stocked but naturally existed in the farm.			0.028	0.138	0.025	0.123

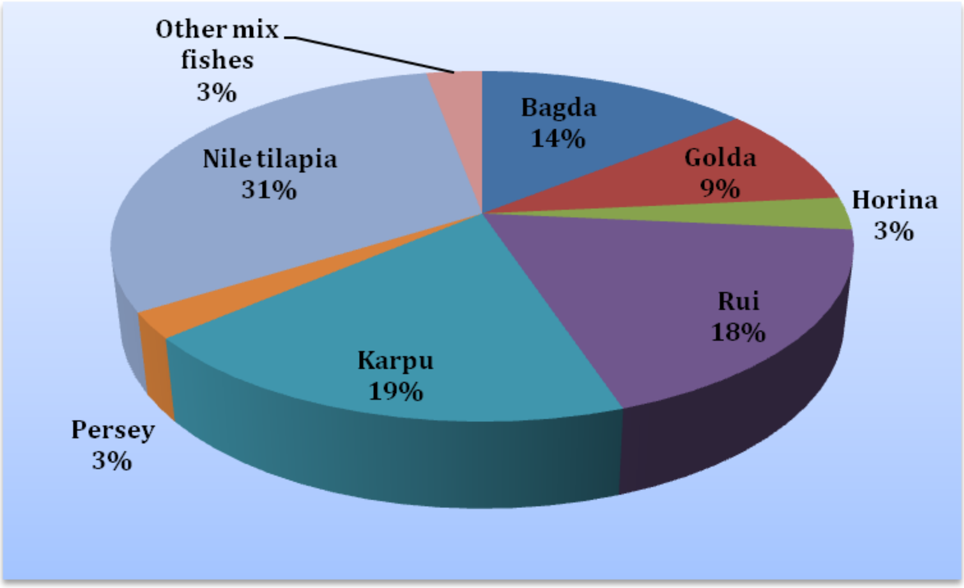

Figure 4.15. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture system in Gauromva, Rampal fish farm in 2013

The water quality parameters were as follows. Temperature range: 13-39°C; Salinity range: 0-14; pH range: 6.8-7.8; DO range: 3.9-5.5.

4.6.2. Gauromva, Rampal shrimp pond production in 2014

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 134 kg was harvested. Per hector production was 0.661 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 83 Kg and per hector production was 0.410 MT. Horina (*Metapepaeus monoceros*) was harvested in total 28 Kg and per hector production was 0.138 MT. Rui (*Labeo rohita*) was harvested 179 Kg and per hector production was 0.884 MT. Karpu (*Cyprinus carpio*) was harvested 176 Kg and per hector production was 0.869 MT. Persey (*Mugil persia*) was harvested 28 Kg and per hector production was 0.138 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 294 Kg and per hector production was 1.452 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus* *tengara*) and some other species of fishes also exist in the farm. Total production of other species was 25 Kg and per hector production was 0.123 MT.

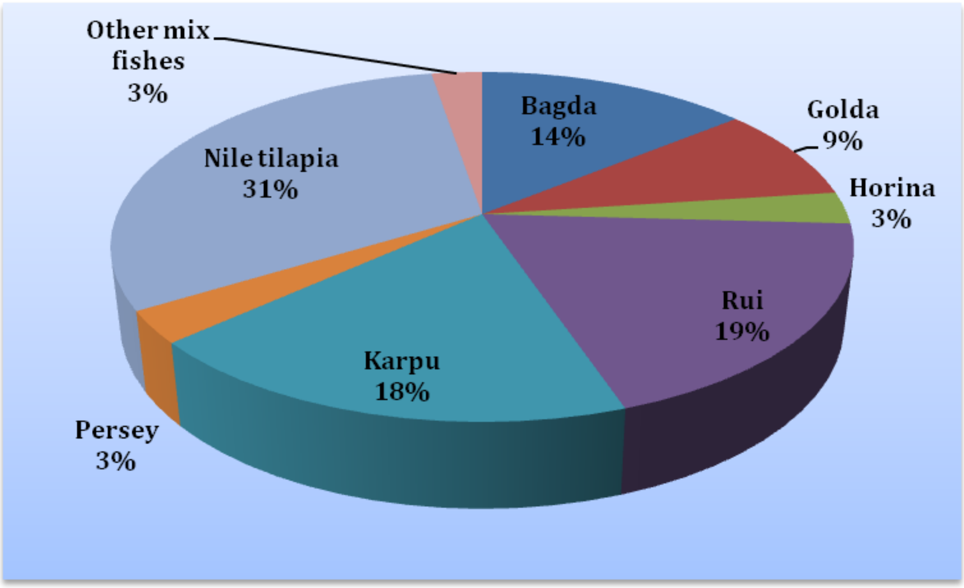

Figure 4.16. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture system in Gauromva, Rampal fish farm in 2014

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 14% , Golda (*Macrobrachium rosenbergii*) 9% and Horina (Metapepaeus monoceros) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 26%. Other fishes like Rui (*Labeo rohita*) is 19%, Karpu (*Cyprinus carpio*) 18%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 31% & mix fishes is 3% &total production of other fishes is 74% in the year 2013 in Gauromva, Rampal fish farm in the improved extensive culture system in case of farms having water exchange facility.

The water quality parameters were as follows. Temperature range: 13.5-38°C; Salinity range: 0-12; pH range: 6.8-7.6; DO range: 4.10-5.30

4.6.4. Comparison of production for the year 2013 and 2014 in Gauromva, Rampal shrimp farm

Gauromva fish farm, Rampal was an improved extensive shrimp culture farms having water exchange facility.

Figure 4.17 shows that the production of Bagda (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*), Horina (*Metapepaeus monoceros*), Karpu (*Cyprinus carpio*) is better in the year 2013 than 2014 & Rui (*Labeo rohita*) is better in the year 2014 than 2013.

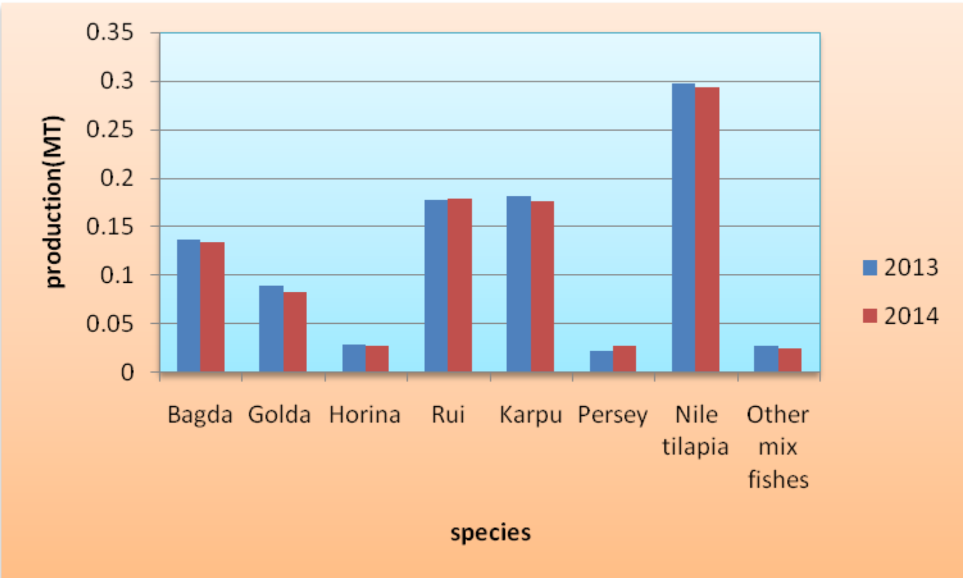

Figure 4.17. The production of Bagda (*Penaeus monodon*) and other fishes in Gouromva, Rampal in the improved extensive culture system in 2013 & 2014

4.6.5. Statistical comparison of production for the year 2013 and 2014 in Gouromva, Rampal fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.12038 Mt, SD = 0.097) and 2014 (M = 0.11838 Mt, SD = 0.095) was not significantly different ($t(7)$ = 1.4676, p= .186).

4.7. Jhanjhania, Rampal shrimp pond

The farm area was 30 Decimals, i.e. 0.121 Hectare, located at Jhanjhania, Rampal, beside a canal. There were water exchange facilities. The gher was improved extensive culture for shrimp. The culture period was February to November, 2013. The data are represented in Table 4.7.

4.7.1. Production of Jhanjhania, Rampal shrimp pond in 2013

In improved extensive culture system, scientifically all activities are not practiced. Pond preparation is not done and stocking density and species combination are not done properly. But to conduct the research a minimum farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. Stocking density and species combination was also maintained to observe the result.

In the mid-February, 2013 farm owner started stocking 1500 PL of Bagda chingri (*Penaeus monodon*). After 14 days he stocked additional 1,000 Bagda (*Penaeus monodon*) PL. In mid-March another batch of 1,000 PL were stocked and at the end of March 1,000 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 4,500 in 0.121-hectare water body in nine month of culture. First two batches PL was collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 60-70 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 5,000 PL of Horina chingri (*Metapenaeus monoceros*) and 1000 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn’t apply feed, entirely dependent on natural feed. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 2,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 200 pieces of Rui (*Labeo rohita*) of average weight 100 g, 150 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,000 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided partially or very few for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied at times, not regularly and without maintaining proper proportion of ingredients and feeding time. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in every year in case of Bagda (*Penaeus monodon*) and finally 49 kg was harvested. Per hector production was 0.403 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 42 Kg and per hector production was 0.345 MT. Horina (*Metapepaeus monoceros*) was harvested in total 12 Kg and per hector production was 0.263 MT. Rui (*Labeo rohita*) was harvested 77 Kg and per hector production was 0.633 MT. Karpu (*Cyprinus carpio*) was harvested 82 Kg and per hector production was 0.675 MT. Persey (*Mugil persia*) was harvested 19 Kgs and per hector production was 0.156 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 170 Kg and per hector production was 1.399 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 16 Kg and per hector production was 0.131s MT

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus

Table 4.7. The production of fishes in Jhanjhania, Rampal fish farm in February to November 2013 & 2014

Name of Species	**Number of PL/fries Stocked**	**Stocking Number/Ha**	**Stocking Frequency**	**2013 Total Production (MT)**	**2013 Unit Production (MT/ Ha)**	**2014 Total Production (MT)**	**2014 Unit Production (MT/ Ha)**
Bagda *(Penaeus monodon)*	4500	37050	4	0.049	0.403	0.051	0.419
Golda *(Macrobrachium rosenbergii)*	2000	16467	1	0.042	0.345	0.047	0.386
Horina *(Metapepaeus monoceros)*	5000	41167	1	0.012	0.263	0.014	0.115
Rui *(Labeo rohita)*	200	1647	1	0.077	0.633	0.078	0.757
Karpu *(Cyprinus carpio)*	150	1235	1	0.082	0.675	0.080	0.658
Persey *(Mugil persia)*	1000	8233	1	0.019	0.156	0.018	0.148
Nile tilapia *(Oreochromis niloticus)*	1000	8233	1	0.170	1.399	0.168	1.383
Other mix fishes	Not stocked but naturally existed in the farm.			0.016	0.131	0.017	0.139

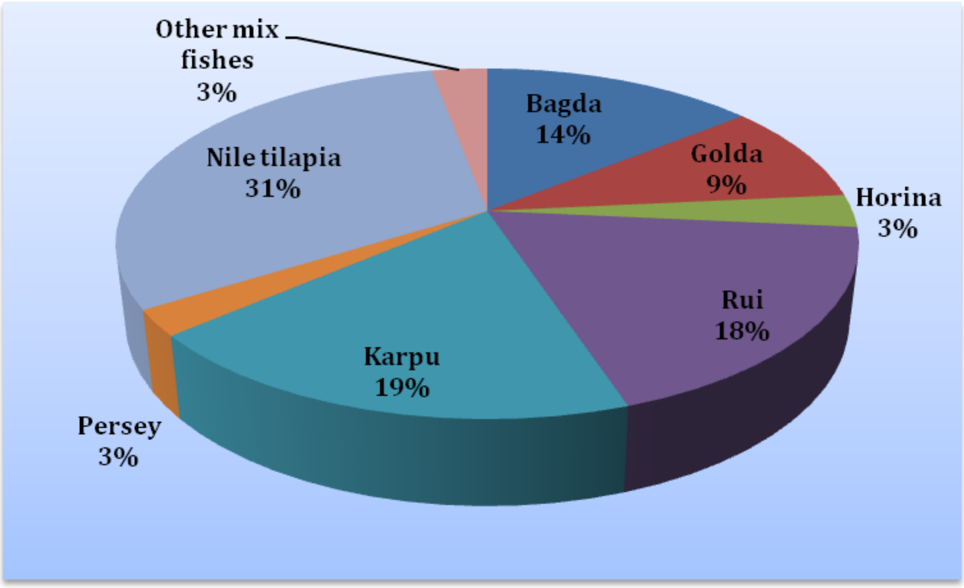

Figure 4.18. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture system in Jhanjhania, Rampal fish farm in 2013

monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 14%, Golda (*Macrobrachium rosenbergii*) 9% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 26%. Other fishes like Rui (*Labeo rohita*) is 18%, Karpu (*Cyprinus carpio*) 19%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 31% & mix fishes is 3% &total production of other fishes is 74% in the year 2013 in Jhanjhania, Rampalfish farm in the improved extensive culture system in case of farms having water exchange facility.

The water quality parameters were as follows. The water temperature range: 13.5-38°C; Salinity range: 0-12; pH range: 6.8-7.6; DO range: 4.10-5.30

4.7.2. Production of Jhanjhania, Rampal **shrimp pond in 2014**

The water exchange facilities were maintained from the adjacent canal. The gher was improved extensive culture system for shrimp. The culture period was February to November, 2014.

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e. overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 51 kg was harvested. Per hector production was 0.419 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 47 Kg and per hector production was 0.386 MT. Horina (*Metapepaeus monoceros*) was harvested in total 14 Kg and per hector production was 0.115 MT. Rui (*Labeo rohita*) was harvested 78 Kg and per hector production was 0.757 MT. Karpu (*Cyprinus carpio*) was harvested 80 Kg and per hector production was 0.658 MT. Persey (*Mugil persia*) was harvested 18 Kgs and per hector production was 0.148 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 168 Kg and per hector production was 1.383 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 17 Kg and per hector production was 0.139 MT.

The water temperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

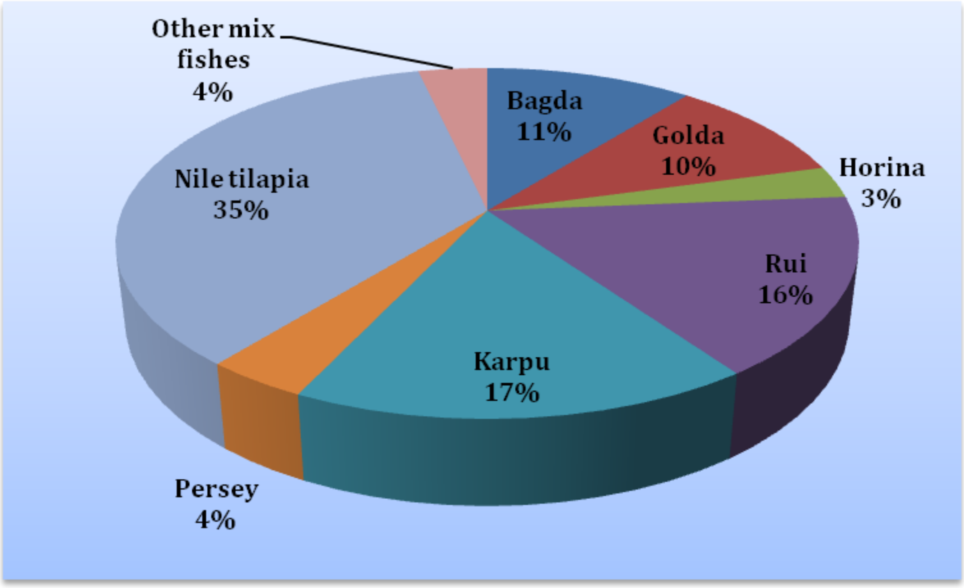

Figure 4.19. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture system in Jhanjhania, Rampal fish farm in 2014

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 11%, Golda (*Macrobrachium rosenbergii*) 10% and Horina (*Metapepaeus monoceros*) is 3% &total production of Chingri (*Bagda (Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 24%. Other fishes like Rui (*Labeo rohita*) is 16%, Karpu (*Cyprinus carpio*) 17%, Persey (*Mugil persia*) 4%, Nile tilapia (*Oreochromis niloticus*) 35% & mix fishes is 4% &total production of other fishes is 76% in the year 2014 in Jhanjhania, Rampal fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.7.4. Comparison of production for the year 2013 and 2014 in Jhanjhania, Rampal fish farm

Figure 4.20. shows that the production of, other fishes is better in the year 2013 than 2014 and Bagda (*Penaeus monodon*), Golda, Horina (*Metapepaeus monoceros*), is better in the year 2014 than 2013.

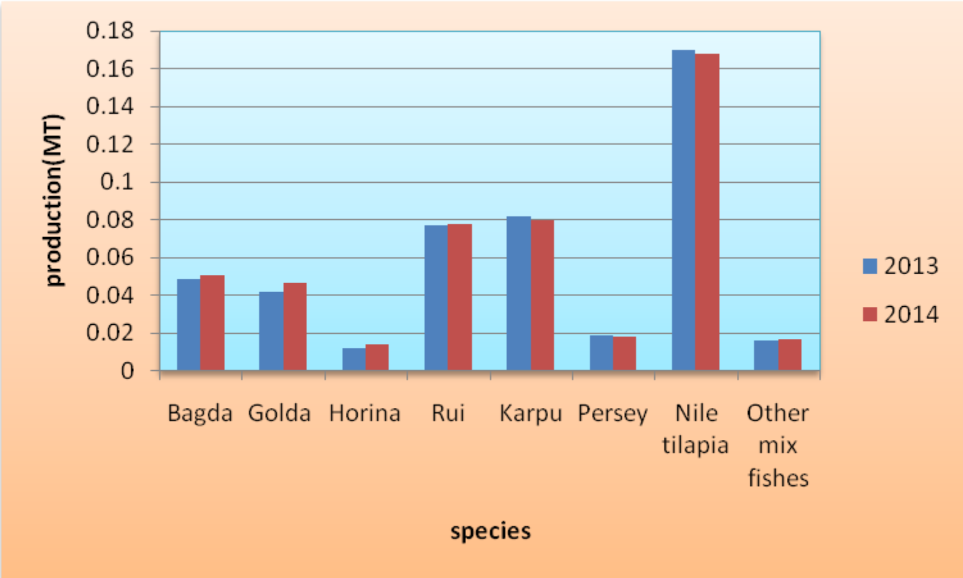

Figure 4.20. The production of Bagda (*Penaeus monodon*) and other fishes in Jhanjhania, Rampal in the improved extensive culture system in 2013 & 2014

4.7.5. Statistical comparison of production for the year 2013 and 2014 in Jhanjhania, Rampal fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.05838 Mt, SD = 0.052) and 2014 (M = 0.05913 Mt, SD = 0.051) was not significantly different ($t(7)$ = 0.8930, p= .402).

4.8. Foyla shrimp pond, Rampal

The farm area was 50 Decimals, i.e., 0.202 Hectare, located at Foyla, Rampal, beside a canal. There were no water exchange facilities, stagnant waterbody. The gher was improved extensive culture system for shrimp. The culture period was February, 2013 to November, 2013.

4.8.1. Production of Foyla shrimp pond, Rampal in 2013

Temperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Under extensive culture system, scientifically all activities are not practiced. Pond preparation is not done and stocking density and species combination are not done properly. But to conduct the research a minimum farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. Stocking density and species combination was also maintained to observe the result.

In the mid-February, 2013 farm owner started stocking 1500 PL of Bagda chingri (*Penaeus monodon*). After 14 days he stocked additional 1,000 Bagda (*Penaeus monodon*) PL. In mid-March another batch of 1,000 PL were stocked and at the end of March 1,000 PL of Bagda (*Penaeus monodon*) were introduced. So in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 4,500 in 0.121 hectare water body in nine month of culture. First two batches PL were collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 60-70 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 5,000 PL of Horina (*Metapepaeus monoceros*) chingri (Metapenaeus monoceros) and 1000 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed, entirely dependent on natural feed. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 2,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 200 pieces of Rui (Labeo rohita) (*Labeo rohita*) of average weight 100 g, 150 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,000 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided partially or very few for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied at times, not regularly and without maintaining proper proportion of ingredients and feeding time. For fin fishes some rice bran, mastered oil cake were applied at noon but not in regular basis as well as without right proportion.

Table 4.8. The production of fishes in Foyla, Rampal fish farm in February to November 2013 & 2014

Name of Species	**Number of PL/fries Stocked**	**Stocking Number/Ha**	**Stocking Frequency**	**2013 Total Production (MT)**	**2013 Unit Production (MT/ Ha)**	**2014 Total Production (MT)**	**2014 Unit Production (MT/ Ha)**
Bagda (*Penaeus monodon*)	4500	37050	4	0.048	0.395	0.046	0.378
Golda (*Macrobrachium rosenbergii*)	2000	16467	1	0.041	0.337	0.041	0.337
Horina (*Metapepaeus monoceros*)	5000	41167	1	0.013	0.107	0.013	0.107
Rui (*Labeo rohita*)	200	1647	1	0.079	0.650	0.077	0.633
Karpu (*Cyprinus carpio*)	150	1235	1	0.078	0.642	0.078	0.642
Persey (*Mugil persia*)	1000	8233	1	0.015	0.123	0.015	0.123
Nile tilapia (*Oreochromis niloticus*)	1000	8233	1	0.174	1.432	0.176	1.449
Other mix fishes	Not stocked but naturally existed in the farm.			0.017	0.140	0.016	0.131

Mortality happened in every year in case of Bagda (*Penaeus monodon*) and finally 48 kg was harvested. Per hector production was 0.395 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 41 Kg and per hector production was 0.337 MT. Horina (*Metapepaeus monoceros*) was harvested in total 13 Kg and per hector production was 0.107 MT. Rui (*Labeo rohita*) was harvested 79 Kg and per hector production was 0.650 MT. Karpu (*Cyprinus carpio*) was harvested 78 Kg and per hector production was 0.642 MT. Persey (*Mugil persia*) was harvested 15 Kgs and per hector production was 0.123 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 174 Kg and per hector production was 1.432 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 17 Kg and per hector production was 0.140 MT.

Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

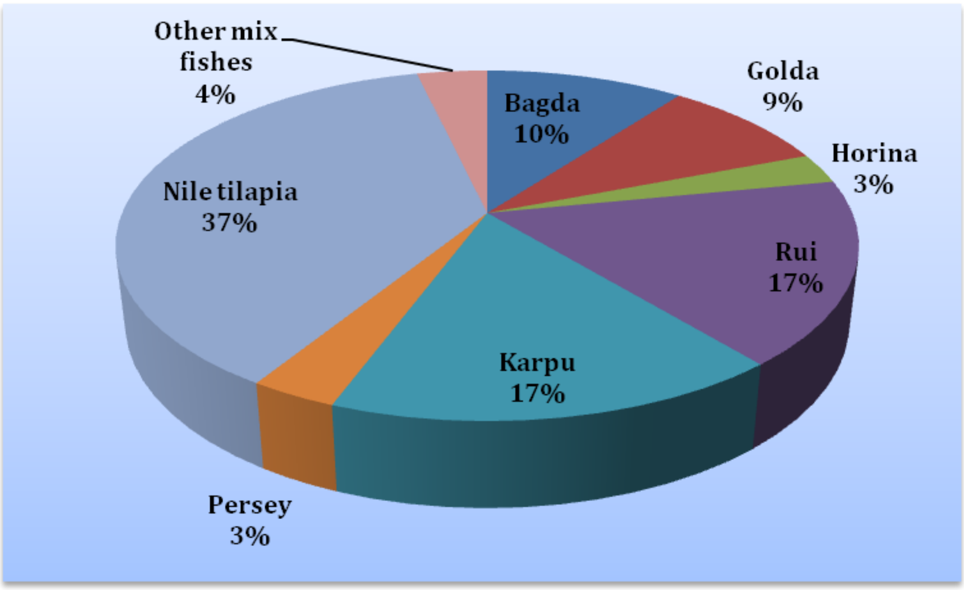

Figure 4.21: The production percentage of Bagda (*Penaeus monodon*) and other fishes in extensive culture systemin Foyala, Rampal fish farm in 2013

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 10%, Golda (*Macrobrachium rosenbergii*) 9% and Horina (Metapepaeus *monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 22%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 17%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 37% & mix fishes is 4% &total production of other fishes is 78% in the year 2013 in Foyala, Rampal, Mongla fish farm in the improved extensive culture system in case of farms having no water exchange facility.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

4.8.2. Production of Foyla shrimp pond, Rampal in 2014

The culture period was February to November, 2014. The water quality parameters were as follows. Temperature range: 13.5-38°C; Salinity range: 0-12; pH range: 6.8-7.6; DO range: 4.10-5.30

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e. overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 46 kg was harvested. Per hector production was 0.378 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 41 Kg and per hector production was 0.337 MT. Horina (*Metapepaeus monoceros*) was harvested in total 13 Kg and per hector production was 0.107 MT. Rui (*Labeo rohita*) was harvested 77 Kg and per hector production was 0.633 MT. Karpu (*Cyprinus carpio*) was harvested 78 Kg and per hector production was 0.642 MT. Persey (Mugil persia) was harvested 15 Kg and

Table 4.9. The production of fishes in Tekatia, Fakirhat fish farm in February to November 2013 & 2014

Name of Species	**Number of PL/fries Stocked**	**Stocking Number/Ha**	**Stocking Frequency**	**2013 Total Production (MT)**	**2013 Unit Production (MT/ Ha)**	**2014 Total Production (MT)**	**2014 Unit Production (MT/ Ha)**
Bagda (*Penaeus monodon*)	11000	54340	5	0.083	0.410	0.095	0.469
Golda (*Macrobrachium rosenbergii*)	4000	19760	1	0.102	0.503	0.129	0.637
Horina (*Metapepaeus monoceros*)	10000	49400	1	0.028	0.138	0.06	0.296
Rui (*Labeo rohita*)	350	1729	1	0.201	0.992	0.28	1.383
Karpu (*Cyprinus carpio*)	250	1235	1	0.196	0.968	0.26	1.284
Persey (*Mugil persia*)	1500	7410	1	0.031	0.153	0.031	0.153
Nile tilapia (*Oreochromis niloticus*)	1500	7410	1	0.401	1.980	0.80	3.952
Other mix fishes	Not stocked but naturally existed in the farm.			0.021	0.163	0.026	0.128

per hector production was 0.123 MT. Nile tilapia (Oreochromis niloticus) was harvested 176 Kg and per hector production was 1.449 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus gulio*) and some other species of fishes also exist in the farm. Total production of other species was 16 Kg and per hector production was 0.131 MT.

4.8.3. Comparison of production of Foyla shrimp pond, Rampal in 2013 and 2014

Figure 4.23 shows that the production of, Bagda (*Penaeus monodon*) & Rui (*Labeo rohita*) is better in the year 2013 than 2014 & Golda, Horina (*Metapepaeus monoceros*), other fishes are same in the year 2014 than 2013 in**,** Foyla, Rampal fish farm in the extensive culture system in case of farms having no water exchange facility.

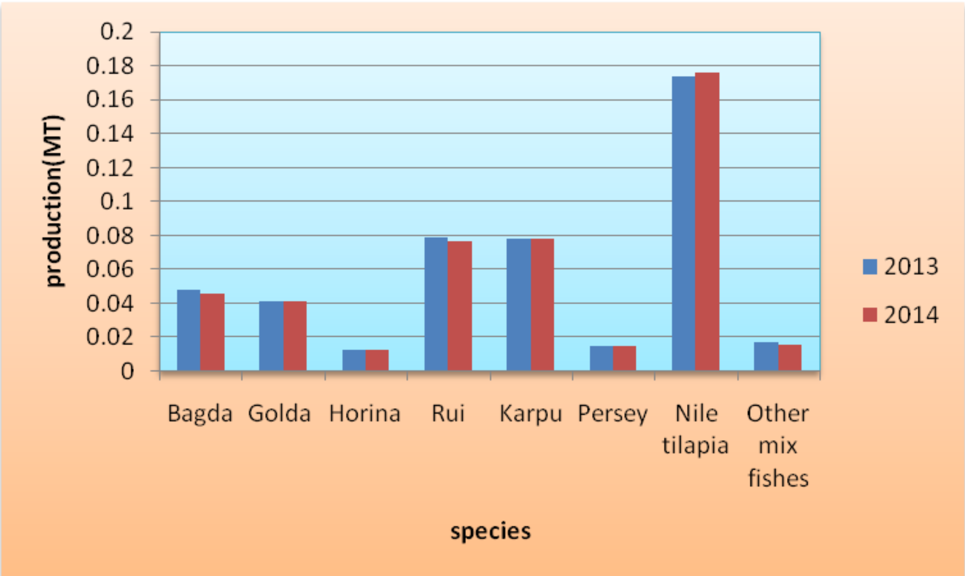

Figure 4.22. The production of Bagda (*Penaeus monodon*) and other fishes in Foyla, Rampal in the extensive culture system in 2013 & 2014

4.8.5. Statistical comparison of production for the year 2013 and 2014 in Foyla, Rampal fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.05813 Mt, SD = 0.054) and 2014 (M = 0.05775 Mt, SD = 0.054) was not significantly different ($t(7)$ = 0.8143, p= .442).

C. Shrimp farms at Fakirhat Upazila

There were four shrimp farms selected from Fakirhat Upazilla, they are Tekatia, Shattola, Diapara and Bighay.

Two production seasons were considered, of which two farms were practiced improved extensive culture system another was undergoes extensive culture system. Between the improved extensive two one has water exchange facilities and another has no. This was done for all three upazilas. Farm size, stocking density and other management like, liming, fertilization, feeding, water quality management were all most same for each area. We carried out this to observe the production difference in various condition i.e. to identify the responsible factors for shrimp production.

4.9.1. Tekatia, Fakirhat shrimp pond (Table 4.9)

The farm area was 50 Decimals, i.e. 0.202 Hectare, located at Tekatia, Fakirhat, beside a canal. There were water exchange facilities. The gher was operated as improved extensive culture system for shrimp. The culture period was February to November.

4.9.2. Production of Tekatia, Fakirhat shrimp pond in 2013

Farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. In the mid February, 2013 farm owner started stocking 3000 PL of Bagda chingri (*Penaeus monodon*) .After 14 days he stocked additional 3,000 Bagda (*Penaeus monodon*) PL. In mid March another batch of 2,000 PL were stocked. At the end of March 1,500 PL and in mid of April 1,500 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 11,000 in 0.202 hectare water body in nine month of culture. First two batches PL were collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 55-60 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 10,000 PL of Horina chingri (*Metapenaeus monoceros*) and 1500 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed regularly, just threw some boiled broken rice and boiled lentil. No branded feed was used. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 4,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 350 pieces of Rui (*Labeo rohita*) of average weight 100 g, 250 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,500 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied. Feed was applied two times daily at evening and at 10 pm. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in case of Bagda (*Penaeus monodon*) and finally 83 kg was harvested. Per hector production was 0.410 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 102 Kg and per hector production was 0.503 MT. Horina (*Metapepaeus monoceros*) was harvested in total 28 Kg and per hector production was 0.138 MT. Rui (*Labeo rohita*) was harvested 201 Kg and per hector production was 0.992 MT. Karpu (*Cyprinus carpio*) was harvested 196 Kg and per hector production was 0.968 MT. Persey (*Mugil persia*) was harvested 31 Kgs and per hector production was 0.153 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 401 Kg and per hector production was 1.980 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 21 Kg and per hector production was 0.163 MT.

The water quality parameters were as temperature range: 13.5-38°C; Salinity range: 0-08; pH range: 6.8-7.6; and DO range: 4.10-5.30.

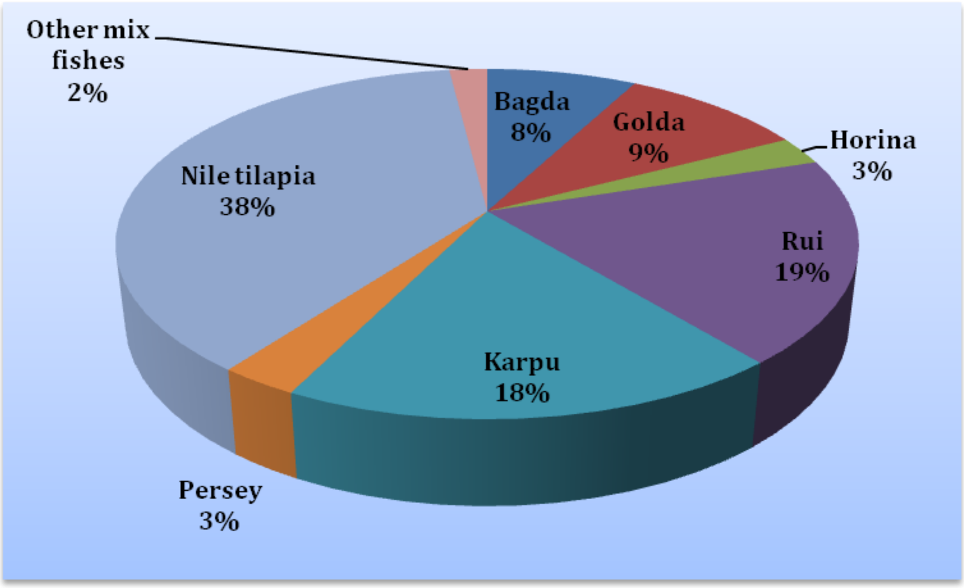

Figure 4.23. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture systemin Tekatia, Fakirhat fish farm in 2013

Figure 4.25. shows that the production of Bagda (*Penaeus monodon*) is 8%, Golda (*Macrobrachium rosenbergii*) 9%and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 20%. Other fishes like Rui (*Labeo rohita*) is 19%, Karpu (*Cyprinus carpio*) 18%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 38% & mix fishes is 2% &total production of other fishes is 80% in the year 2013 in Tekatia, Fakirhat fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.9.3. Production of Tekatia, Fakirhat shrimp pond in 2014

The culture period was February to November, 2014. The water quality parameters were as the water temperature range: 13.5-38°C; Salinity range: 0-08; pH range: 6.8-7.6; DO range: 4.10-5.30 and Salinity range : 0-8

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e. overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 95 kg was harvested. Per hector production was 0.469 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 129 Kg and per hector production was 0.637 MT. Horina (*Metapepaeus monoceros*) was harvested in total 06 Kg and per hector production was 0.296 MT. Rui (*Labeo rohita*) was harvested 28 Kg and per hector production was 1.383 MT. Karpu (*Cyprinus carpio*) was harvested 26 Kg and per hector production was 1.284 MT. Persey (*Mugil persia*) was harvested 31 Kg and per hector production was 0.153 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 80 Kg and per hector production was 3.952 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 26 Kg and per hector production was 0.128 MT.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

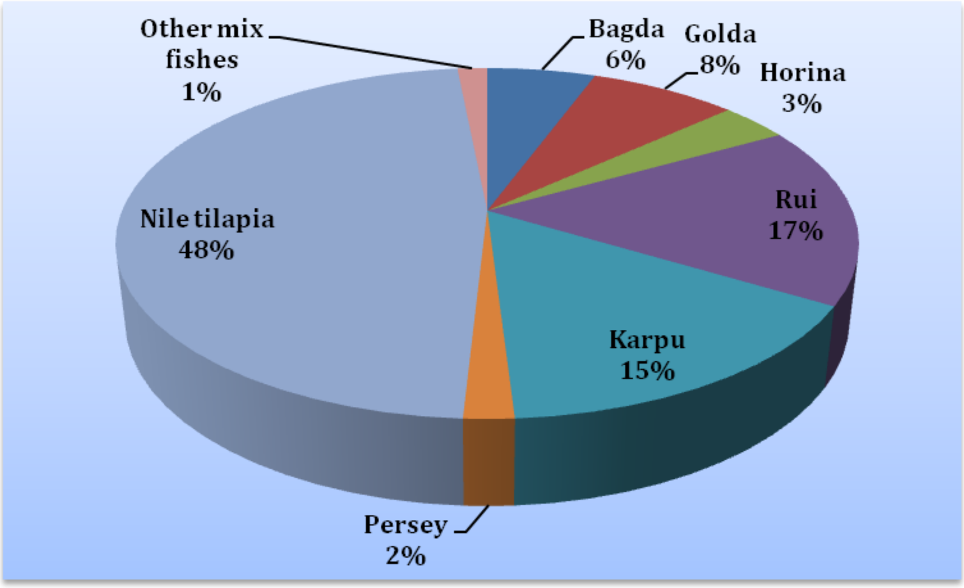

Figure 4.24. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture system in Tekatia, Fakirhat fish farm in 2014

Above Figure 4.26 shows that the production of Bagda (*Penaeus monodon*) is 6%, Golda (*Macrobrachium rosenbergii*) 8% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 17%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 15%, Persey (*Mugil persia*) 2%, Nile tilapia (*Oreochromis niloticus*) 48% & mix fishes is 1% &total production of other fishes is 83% in the year 2014 in Tekatia, Fakirhat fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.9.4. Comparive production of Tekatia, Fakirhat shrimp pond in 2013 and 2014

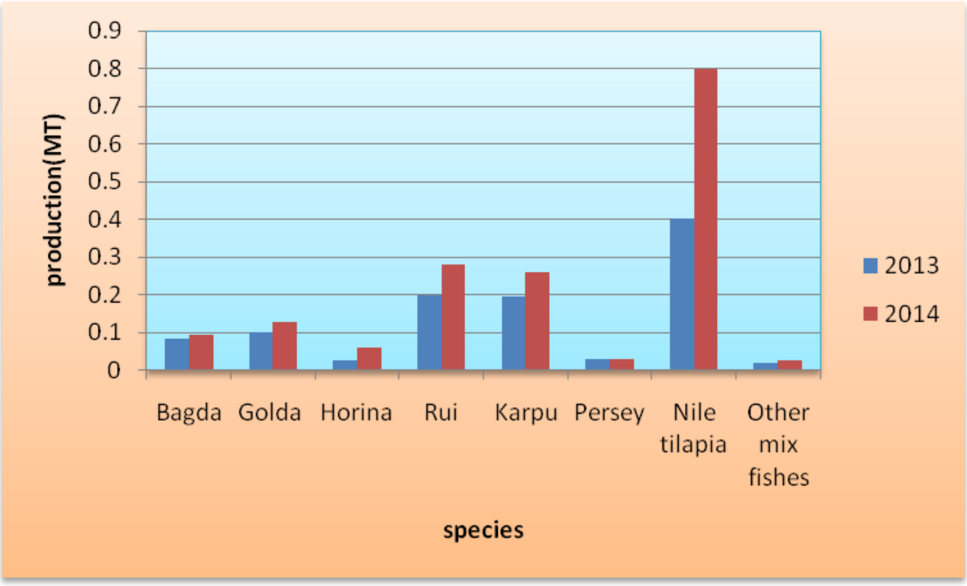

Figure 4.25. The production of Bagda (*Penaeus monodon*) and other fishes in Tekatia, Fakirhat in the improved extensive culture system in 2013 and 2014

Figure 4.27 shows that the production of Bagda (*Penaeus monodon*) and all other fishes is better in the year 2014 than 2013 in**,** Tekatia, Fakirhat fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.9.5. Statistical comparison of production for the year 2013 and 2014 in Tekatia, Fakirhat fish farm

Production data were compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.13288 Mt, SD = 0.130) and 2014 (M = 0.21013 Mt, SD = 0.257) was not significantly different ($t(7)$ = 1.6435, p= .144).

4.10.1. Shattola, Fakirhat shrimp pond (Table 4.10)

The farm area was 50 Decimals, i.e. 0.202 Hectare, located at Shattola, Fakirhat. There were water exchange facilities. The gher was operated as improved extensive culture system for shrimp.

4.10.2. Production of Shattola, Fakirhat shrimp pond in 2013

The culture period was operated from February to November 2013. The water quality parameters were as temperature range: 13.5-38°C; Salinity range: 0-08; pH range: 6.8-7.6; DO range: 4.10-5.30.

Farm preparation of Shattola was done by using lime after that urea and TSP was applied but not in standard ratio. In the mid February, 2013 farm owner started stocking 3000 PL of Bagda chingri (*Penaeus monodon*). After 14 days he stocked additional 3,000 Bagda (*Penaeus monodon*) PL. In mid March another batch of 2,000 PL were stocked. At the end of March 1,500 PL and in mid of April 1,500 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 11,000 in 0.202 hectare water body in nine month of culture. First two batches PL were collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 55-60 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 10,000 PL of Horina chingri (*Metapenaeus monoceros*) and 1500 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed regularly, just threw some boiled broken rice and boiled lentil. No branded feed was used. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 4,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 350 pieces of Rui (*Labeo rohita*) of average weight 100 g, 250 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,500 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied. Feed was applied two times daily at evening and at 10 pm. For fin fishes some rice bran, mastered oil cake were applied at noon but not in regular basis as well as without right proportion.

Mortality happened in case of Bagda (*Penaeus monodon*) and finally 76 kg was harvested. Per hector production was 0.410 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 138 Kg and per hector production was 0.681 MT. Horina

(*Metapepaeus monoceros*) was harvested in total 05 Kg and per hector production was 0.247 MT. Rui (*Labeo rohita*) was harvested 30 Kg and per hector production was 1.482 MT. Karpu (*Cyprinus carpio*) was harvested 28 Kg and per hector production was 1.383 MT. Persey (*Mugil persia*) was harvested 31 Kg and per hector production was 0.153 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 81 Kg and per hector production was 4.001 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 24 Kg and per hector production was 0.118 MT.

Table 4.10. The production of fishes in Shattola, Fakirhat fish farm in February to November 2013 and 2014

Name of Species	**Number of PL/fries Stocked**	**Stocking Number/ Ha**	**Stocking Frequency**	**2013 Total Production (MT)**	**2013 Unit Production (MT/ Ha)**	**2014 Total Production (MT)**	**2014 Unit Production (MT/ Ha)**
Bagda (*Penaeus monodon*)	11000	54340	5	0.076	0.410	0.079	0.390
Golda (*Macrobrachium rosenbergii*)	4000	19760	1	0.138	0.681	0.141	0.696
Horina (*Metapepaeus monoceros*)	10000	49400	1	0.05	0.247	0.028	0.138
Rui (*Labeo rohita*)	350	1729	1	0.30	1.482	0.203	1.002
Karpu (*Cyprinus carpio*)	250	1235	1	0.28	1.383	0.199	0.983
Persey (*Mugil persia*)	1500	7410	1	0.031	0.153	0.034	0.167
Nile tilapia (*Oreochromis niloticus*)	1500	7410	1	0.81	4.001	0.406	2.005
Other mix fishes	Not stocked but naturally existed in the farm.			0.024	0.118	0.025	0.123

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (Penaeus monodon) and Golda (Macrobrachium rosenbergii) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

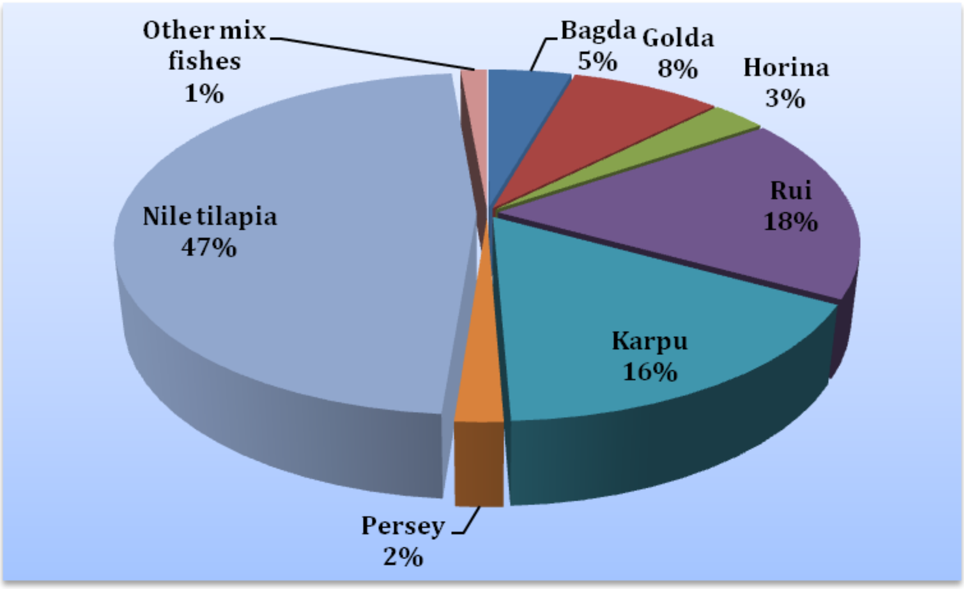

Figure 4.26. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture systemin Shattola, Fakirhat fish farm in 2013 (Table 4.10).

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 5%, Golda(*Macrobrachium rosenbergii*) 8% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (Penaeus monodon), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is

16%. Other fishes like Rui (*Labeo rohita*) is 18%, Karpu (*Cyprinus carpio*) 16%, Persey (*Mugil persia*) 2%, Nile tilapia (*Oreochromis niloticus*) 47% & mix fishes is 1% &total production of other fishes is 84% in the year 2013 in Shattola, Fakirhat fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.10.3. Production of Shattola, Fakirhat shrimp pond in 2014

The culture period was February to November, 2014.

The water quality parameters were as water temperature range: 13.5-38°C; Salinity range: 0-08; pH range: 6.8-7.6; DO range: 4.10-5.30.

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 79 kg was harvested. Per hector production was 0.390 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 141 Kg and per hector production was 0.696 MT. Horina (*Metapepaeus monoceros*) was harvested in total 28 Kg and per hector production was 0.138 MT. Rui (*Labeo rohita*) was harvested 203 Kg and per hector production was 1.002 MT. Karpu (*Cyprinus carpio*) was harvested 199 Kg and per hector production was 0.983 MT. Persey (Mugil persia) was harvested 34 Kg and per hector production was 0.167 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 406 Kg and per hector production was 2.005 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 25 Kg and per hector production was 0.123 MT.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to December, 2014. Temperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (Penaeus monodon) and Golda (Macrobrachium rosenbergii) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

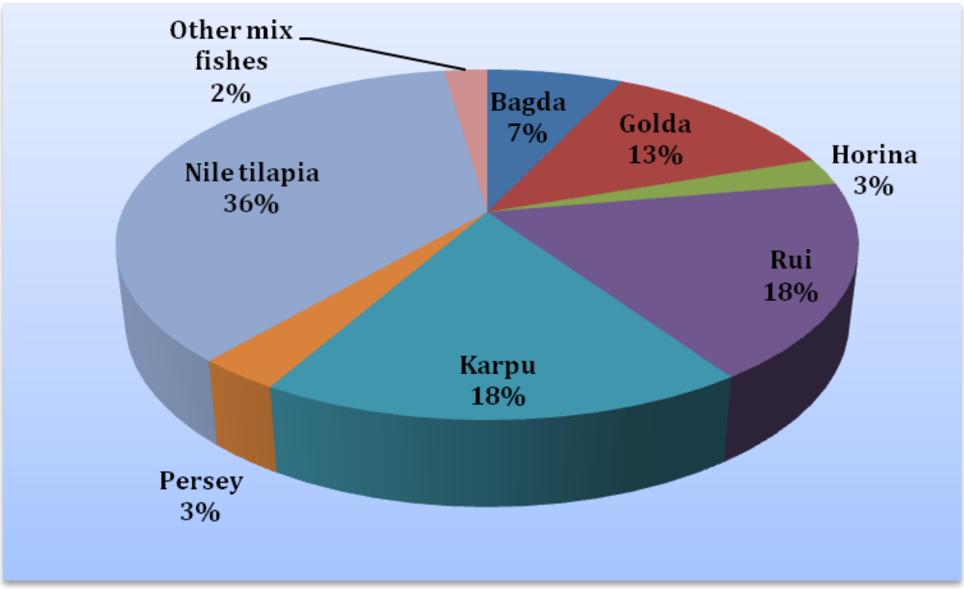

Figure 4.27. The production percentage of Bagda (*Penaeus monodon*) and other fishes in **Improved extensive culture system in Shattola, Fakirhat fish farm in 2014**

Figure 4.29 shows that the production of Bagda (*Penaeus monodon*) is 7%, Golda (*Macrobrachium rosenbergii*) 13% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodo*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 23%. Other fishes like Rui (*Labeo rohita*) is 18%, Karpu (*Cyprinus carpio*) 18%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 36% &

mix fishes is 2% &total production of other fishes is 77% in the year 2014 in Makordon, Mongla fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.10.4. Production for the year 2013 and 2014 in Shattola, Fakirhat fish farm

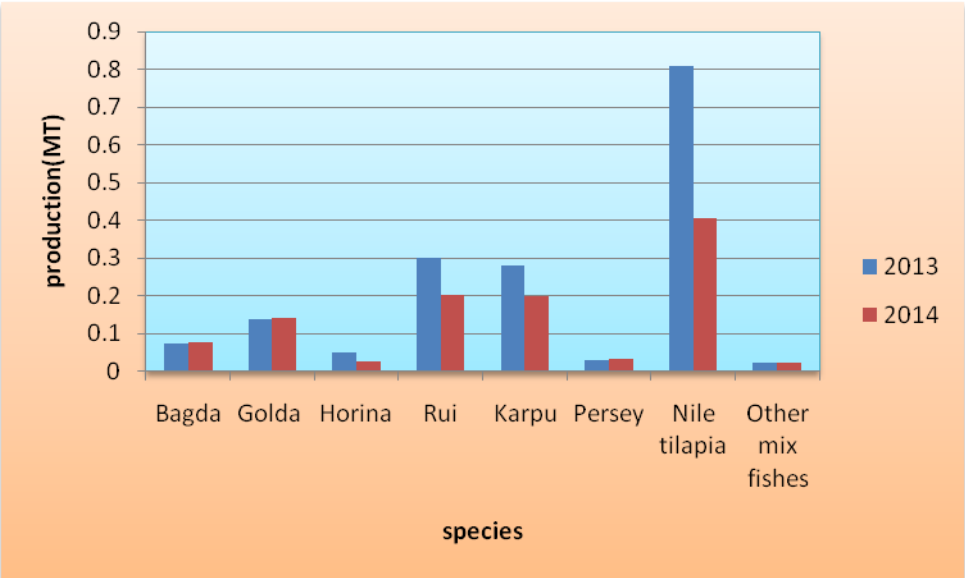

Figure 4.28. The production of Bagda (*Penaeus monodon*) and other fishes in Shattola, Fakirhat in the improved extensive culture system in 2013 and 2014

Figure 4.30 shows that the production of Bagda (*Penaeus monodon*), Horina (*Metapepaeus monoceros*) and other miscellenous fishes is better in the year 2013 than 2014 in Shattola, Fakirhat fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.10.5. Statistical comparison of production for the year 2013 and 2014 in Shattola, Fakirhat fish farm

Production data of Shattola shrimp farm at Fakirhat was compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.21363 Mt, SD = 0.264) and 2014 (M = 0.13937 Mt, SD = 0.130) was not significantly different ($t(7) = 1.5089$, $p = .175$).

4.11. 1. Diapara, Fakirhat shrimp pond was designated

The farm area was 30 Decimals, i.e. 0.121 Hectare, located at Diapara, Fakirhat, beside a canal. There were water exchange facilities. The gher was improved extensive culture system for shrimp. The culture period was February to December, 2014.

The water quality parameters were as follows. Temperature range: 13.5-38°C; Salinity range: 0-08; pH range: 6.8-7.6; DO range: 4.10-5.30.

4.11.2. The production of Bagda (*Penaeus monodon*) and other fishes in Diapara, Fakirhat in 2013

A farm of 50 decimals was taken from Diapara, Fakirhat where two production seasons were observed. Extensive culture system was practiced in this farm as a part of the research. Here the production of 2013 is described (Table. 20).

In Improved extensive culture system, scientifically all activities are not practiced. Pond preparation is not done and stocking density and species combination are not done properly. But to conduct the research a minimum farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. Stocking density and species combination was also maintained to observe the result.

In the mid February, 2013 farm owner started stocking 1500 PL of Bagda chingri (*Penaeus monodon*). After 14 days he stocked additional 1,000 Bagda (*Penaeus monodon*) PL. In mid March another batch of 1,000 PL were stocked and at the end of March 1,000 PL of Bagda (*Penaeus monodon*) were introduced. So, in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 4,500 in 0.121 hectare water body in nine month of culture. First two batches PL were collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 60-70 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 5,000 PL of Horina chingri (*Metapenaeus monoceros*) and 1000 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn’t apply feed, entirely dependent on natural feed. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 2,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 200 pieces of Rui (*Labeo rohita*) of average weight 100 g, 150 pieces of Karpu (*Cyprinus carpio*) of average weight 85 g and 1,000 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided partially or very few for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied at times, not regularly and without maintaining proper proportion of ingredients and feeding time. For fin fishes some rice bran, mastered oil cake was applied at noon but not in regular basis as well as without right proportion.

Mortality happened in every year in case of Bagda (*Penaeus monodon*) and finally 32 kg was harvested. Per hector production was 0.263 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 44 Kg and per hector production was 0.378 MT. Horina (*Metapepaeus monoceros*) was harvested in total 11 Kg and per hector production was 0.090 MT. Rui (*Labeo rohita*) was harvested 90 Kg and per hector production was 0.741 MT. Karpu (*Cyprinus*

Table 4.11. The production of fishes in Diapara, Fakirhat fish farm in February to November 2013 & 2014

Name of Species	Number of PL/fries Stocked	Stocking Number/Ha	Stocking Frequency	2013 Total Production (MT)	2013 Unit Production (MT/ Ha)	2014 Total Production (MT)	2014 Unit Production (MT/ Ha)
Bagda (*Penaeus monodon*)	4500	37050	4	0.032	0.263	0.034	0.279
Golda (*Macrobrachium rosenbergii*)	2000	16467	1	0.046	0.378	0.048	0.395
Horina (*Metapepaeus monoceros*)	5000	41167	1	0.011	0.090	0.012	0.099
Rui (*Labeo rohita*)	200	1647	1	0.090	0.741	0.092	0.757
Karpu (*Cyprinus carpio*)	150	1235	1	0.085	0.700	0.090	0.741
Persey (*Mugil persia*)	1000	8233	1	0.013	0.107	0.015	0.123
Nile tilapia (*Oreochromis niloticus*)	1000	8233	1	0.189	1.556	0.191	1.556
Other mix fishes	Not stocked but naturally existed in the farm.			0.014	0.115	0.016	0.131

carpio) was harvested 85 Kg and per hector production was 0.700 MT. Persey (*Mugil persia*) was harvested 13 Kg and per hector production was 0.107 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 189 Kg and per hector production was 1.556 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 14 Kg and per hector production was 0.115 MT.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (*Penaeus monodon*) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

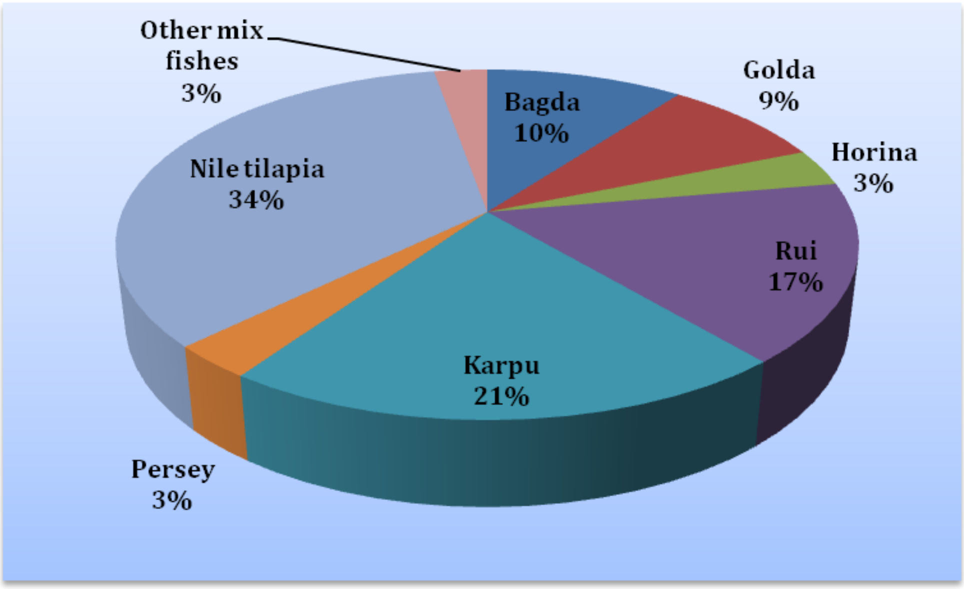

Figure 4.29. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture systemin Diapara, Fakirhat fish farm in 2013

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 10% , Golda (*Macrobrachium rosenbergii*) 9% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*) , Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 22%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 21%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 34% & mix fishes is 3% &total production of other fishes is 78% in the year 2013 in Diapara, Fakirhat fish farm in the improved extensive culture system in case of farms having water exchange facility.

4.11.3. The production of Bagda (*Penaeus monodon*) and other fishes in Diapara, Fakirhat in 2014

The farm area was 30 Decimals, i.e. 0.121 Hectare, located at Diapara, Fakirhat, beside a canal. There were water exchange facilities. The gher was improved extensive culture system for shrimp. The culture period was February to December, 2014.

The water quality parameters were as follows. Temperature range: 13.5-38°C; Salinity range: 0-08; pH range: 6.8-7.6; DO range: 4.10-5.30

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 34kg was harvested. Per hector production was 0.279 MT. Golda (*Macrobrachium rosenbergii*) was harvested 48 Kg and per hector production was 0.395 MT. Horina (*Metapepaeus monoceros*) was harvested in total 12 Kg and per hector production was 0.099 MT. Rui (*Labeo rohita*) was harvested 92 Kg and per hector production was 0.757 MT. Karpu (*Cyprinus carpio*) was harvested 90 Kg and per hector production was 0.741 MT. Persey (*Mugil persia*) was harvested 15 Kg and per hector production was 0.123 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 191 Kg and per hector production was 1.556 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus* *tengara*) and some other species of fishes also exist in the farm. Total production of other species was 16 Kg and per hector production was 0.131 MT.

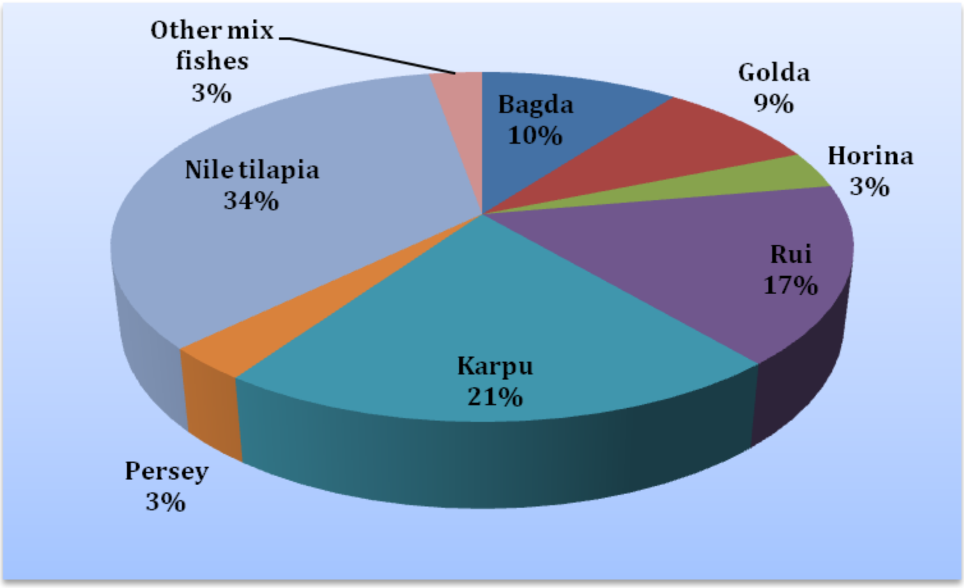

Figure 4.30. The production percentage of Bagda (*Penaeus monodon*) and other fishes in Improved extensive culture system in Diapara, Fakirhat fish farm in 2014

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 10%, Golda (*Macrobrachium rosenbergii*) 9% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*) , Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 22%. Other fishes like Rui (*Labeo rohita*) is 17%, Karpu (*Cyprinus carpio*) 21%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 34% & mix fishes is 3% &total production of other fishes is 78% in the year 2014 in Diapara, Fakirhat fish farm in the improved extensive culture system in case of farms having water exchange facility.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to December, 2013. Temperature v varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16.

Bagda (Penaeus monodon) and Golda (Macrobrachium rosenbergii) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

4.11.4. Comparison of production for the year 2013 and 2014 in Diapara, Fakirhat fish farm

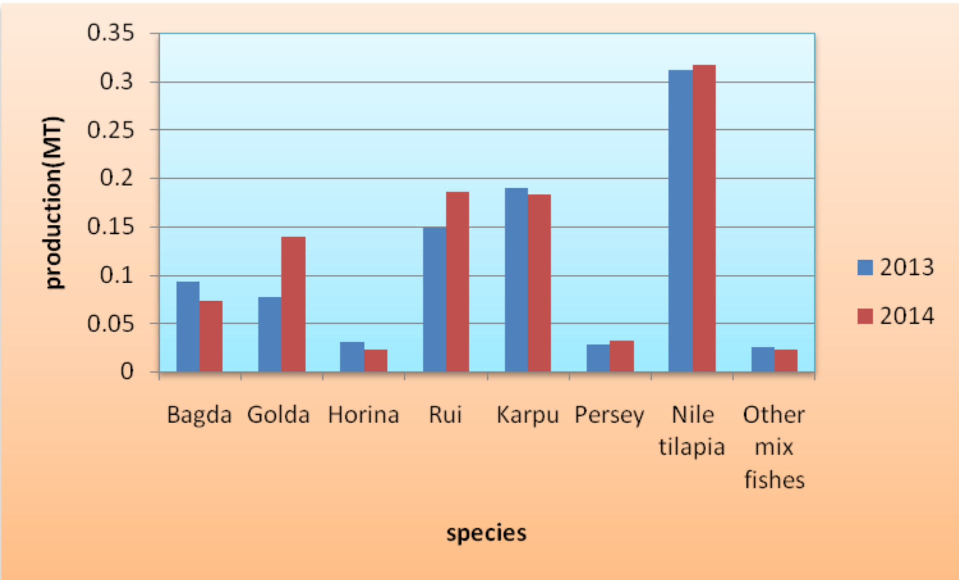

Figure 4.31. The production of Bagda (*Penaeus monodon*) and other fishes in Diapara, Fakirhat in the Improved extensive culture system in 2013 and 2014

Figure 4.33 shows that the production of Bagda (*Penaeus monodon*) , Horina (*Metapepaeus monoceros*), Karpu (*Cyprinus carpio*) is better in the year 2013 than 2014 and Golda (*Macrobrachium rosenbergii*), Rui (*Labeo rohita*) & Nile tilapia (*Oreochromis niloticus*) is better in 2014 in Diapara**,** Fakirhat fish farm in the Improved extensive culture system in case of Farms having water exchange facilitiy.

4.11.5. Statistical comparison of production for the year 2013 and 2014 in Diapara, Fakirhat fish farm

Production data of Diapara shrimp farm at Fakirhat was compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.06000 Mt, SD = 0.061) and 2014 (M = 0.06225 Mt, SD = 0.061) was highly significantly different ($t(7) = 5.4628$, $p = .0009$).

4.12.1. Bighay, Fakirhat shrimp pond (Table 4.12)

The farm area was 30 Decimals, i.e. 0.121 Hectare, located at Bighay, Fakirhat. There was water no exchange facilities, stagnant waterbody. The gher was improved extensivee culture system for shrimp.

4.12.2. The production of Bighay, Fakirhat in 2013

A farm of 30 decimals was taken from Bighay, Fakirhat where two production seasons were observed. Extensive culture system was practiced in this farm as a part of the research.

In extensive culture system, scientifically all activities are not practiced. Pond preparation is not done and stocking density and species combination are not done properly. But to conduct the research a minimum farm preparation was done by using lime after that urea and TSP was applied but not in standard ratio. Stocking density and species combination was also maintained to observe the result.

In the mid February, 2013 farm owner started stocking 1500 PL of Bagda (Penaeus monodon) chingri (*P. monodon*). After 14 days he stocked additional 1,000 Bagda (*Penaeus monodon*) PL. In mid March another batch of 1,000 PL were stocked and at the end of March 1,000 PL of Bagda (*Penaeus monodon*) were introduced. So in every 14 days PL of Bagda (*Penaeus monodon*) were stocked and the total was 4,500 in 0.121 hectare water body in nine month of culture. First two batches PL was collected from natural source and other from hatcheries. The first harvest started in two and half months of culture when shrimp reach in a size of 60-70 pieces/kg. Simultaneously with Bagda (*Penaeus monodon*) 5,000 PL of Horina chingri

(*Metapepaeus monoceros*) and 1000 pieces of Parsey (*Mugil persia*) were stocked. For Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) farmer didn't apply feed, entirely dependent on natural feed. By June all Bagda (*Penaeus monodon*) and Horina (*Metapepaeus monoceros*) were harvested and 2,000 PL of Golda chingri (*Macrobrachium rosenbergii*) were stocked. Simultaneously some freshwater fin fishes were stocked. 200 pieces of Rui (*Labeo rohita*) (*Labeo rohita*) of average weight 100 g, 150 pieces of Karpu ((*Cyprinus carpio*) of average weight 85 g and 1,000 pieces of Nile tilapia (*Oreochromis niloticus*) were stocked. Feed was provided partially or very few for Golda (*Macrobrachium rosenbergii*) and fin fishes. Snail meat, boiled broken rice and lentil were applied at times, not regularly and without maintaining proper proportion of ingredients and feeding time. For fin fishes some rice bran, mastered oil cake were applied at noon but not in regular basis as well as without right proportion.

Mortality happened in every year in case of Bagda (*Penaeus monodon*) and finally 31 kg was harvested. Per hector production was 0.255 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 48 Kg and per hector production was 0.395 MT. Horina (*Metapepaeus monoceros*) was harvested in total 11 Kg and per hector production was 0.090 MT. Rui (*Labeo rohita*) was harvested 92 Kg and per hector production was 0.757 MT. Karpu (*Cyprinus carpio*) was harvested 87 Kg and per hector production was 0.716 MT. Persey (*Mugil persia*) was harvested 12 Kgs and per hector production was 0.098 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 191 Kg and per hector production was 1.572 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*),

Table 4.12. The production of fishes in Bighay, Fakirhat fish farm in February to November 2013 and 2014

Name of Species	Number of PL/fries Stocked	Stocking Number/Ha	Stocking Frequency	2013 Total Production (MT)	2013 Unit Production (MT/ Ha)	2014 Total Production (MT)	2014 Unit Production (MT/ Ha)
Bagda (*Penaeus monodon*)	4500	37050	4	0.031	0.255	0.036	0.296
Golda (*Macrobrachium rosenbergii*)	2000	16467	1	0.048	0.395	0.049	0.403
Horina (*Metapepaeus monoceros*)	5000	41167	1	0.011	0.090	0.012	0.098
Rui (*Labeo rohita*)	200	1647	1	0.092	0.757	0.089	0.732
Karpu (*Cyprinus carpio*)	150	1235	1	0.087	0.716	0.087	0.716
Persey (*Mugil persia*)	1000	8233	1	0.012	0.098	0.013	0.140
Nile tilapia (*Oreochromis niloticus*)	1000	8233	1	0.191	1.572	0.189	1.556
Other mix fishes	Not stocked but naturally existed in the farm.			0.013	0.123	0.012	0.098

Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 13 Kg and per hector production was 0.123 MT.

The farm was situated beside a canal and water was exchanged during culture period. Improved extensive culture system was practiced in this farm. Culture period was February, 2013 to November, 2013. Temperature varied from 13.5-38°C. Dissolved oxygen varied from 4.10-5.30. pH varied from 6.8-7.6 and Salinity varied from 0-16. Bagda (*Penaeus monodon*) and Golda (*Macrobrachium rosenbergii*) production is not satisfactory according to stocking number but this practice very common in this area. Mortality normally happened when Bagda (Penaeus monodon) reach in a size of 80-90 pieces per Kg. After mortality fin fishes are stocked to mitigate the loss.

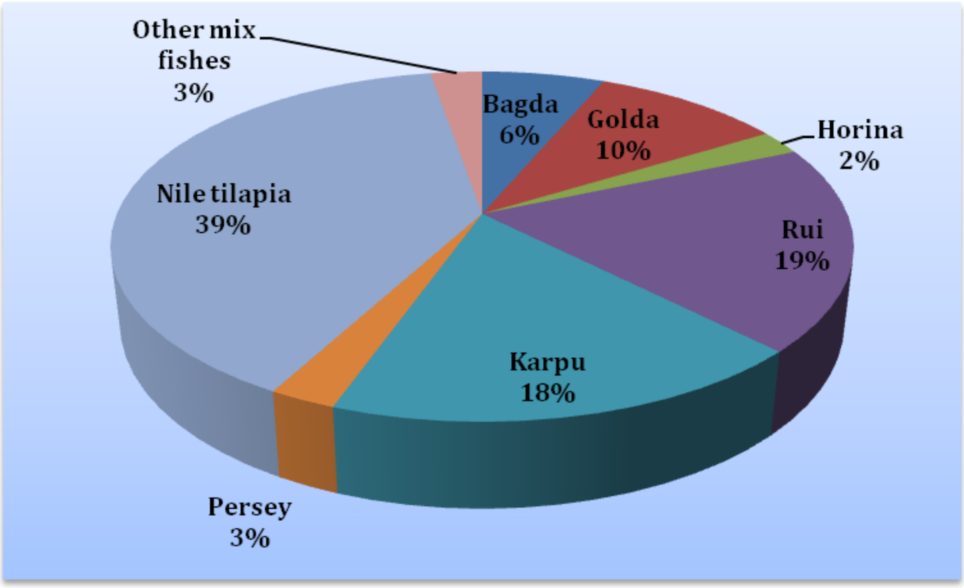

Figure 4.32. The production percentage of Bagda (*Penaeus monodon*) and other fishes in extensive culture systemin Bighay, Fakirhat fish farm in 2013

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 6%, Golda (Macrobrachium rosenbergii) 10% and Horina (*Metapepaeus monoceros*) is 2% &total production of Bagda Chingri (Penaeus monodon), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*)) is 18%. Other fishes like Rui (*Labeo rohita*) is 19%, Karpu (*Cyprinus carpio*) 18%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 39% & mix fishes is 3% &total production of other fishes is 82% in the year 2013 in Bighay, Fakirhat fish farm in the extensive culture system in case of farms having no water exchange facility.

4.12.3. The production of Bighay, Fakirhat in 2014

The water quality parameters were as the temperature range: 13.5-38°C; Salinity range: 0-08; pH range: 6.8-7.6; and DO range: 4.10-5.30.

Farm preparation, stocking density, stocking frequencies, species combination, stocking time, feeding i.e. overall pre stocking and post stocking management was same as previous year. Mortality happened in case of Bagda (*Penaeus monodon*) and finally 36 kg was harvested. Per hector production was 0.296 MT. Golda (*Macrobrachium rosenbergii*) was harvested as 49 Kg and per hector production was 0.403 MT. Horina (*Metapepaeus monoceros*) was harvested in total 12 Kg and per hector production was 0.098 MT. Rui (*Labeo rohita*) was harvested 89 Kg and per hector production was 0.732 MT. Karpu (*Cyprinus carpio*) was harvested 87 Kg and per hector production was 0.716 MT. Persey (*Mugil persia*) was harvested 13 Kg and per hector production was 0.140 MT. Nile tilapia (*Oreochromis niloticus*) was harvested 189 Kg and per hector production was 1.556 MT. Some other species like Chaka chingri (*Fenneropenaeus indicus*), Vetki (*Lates calcarifer*), Tangra (*Mystus tengara*) and some other species of fishes also exist in the farm. Total production of other species was 12 Kg and per hector production was 0.098 MT.

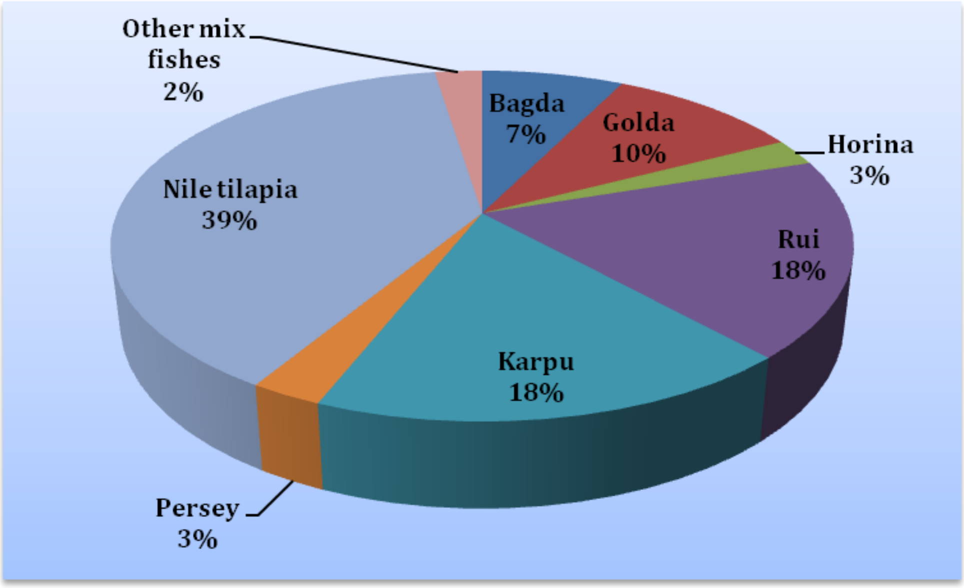

Figure 4.33. The production percentage of Bagda (*Penaeus monodon*) and other fishes in extensive culture system in Bighay, Fakirhat fish farm in 2014

Above Figure shows that the production of Bagda (*Penaeus monodon*) is 7%, Golda (*Macrobrachium rosenbergii*) 10% and Horina (*Metapepaeus monoceros*) is 3% &total production of Bagda Chingri (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) and Horina (*Metapepaeus monoceros*) is 20%. Other fishes like Rui (*Labeo rohita*) are 18%, Karpu (*Cyprinus carpio*) 18%, Persey (*Mugil persia*) 3%, Nile tilapia (*Oreochromis niloticus*) 39% & mix fishes is 3% &total production of other fishes is 80% in the year 2014 in Bighay, Fakirhat fish farm in the extensive culture system in case of farms having no water exchange facility.

4.12.4. Comparison of production for the year 2013 and 2014 in Bighay, Fakirhat fish farm

Figure 4.36 shows that the production of Bagda (*Penaeus monodon*), Golda (*Macrobrachium rosenbergii*) Horina (*Metapepaeus monoceros*) in the year 2014 than 2013 & other fishes is better in 2013 in Bighay, Fakirhat fish farm in the extensive culture system in case of Farms having no water exchange facility.

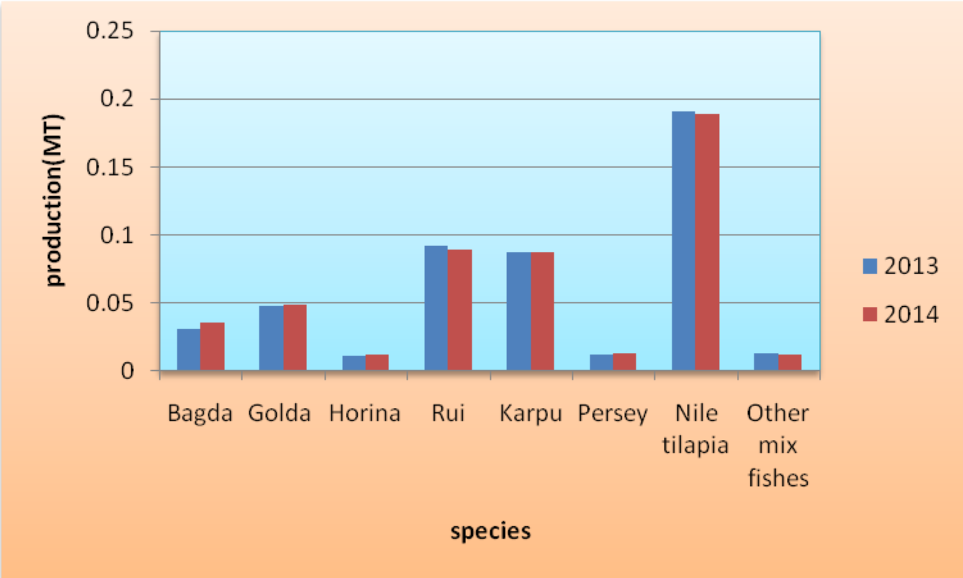

Figure 4.34. The production of Bagda (*Penaeus monodon*) and other fishes in Bighay, Fakirhat in the extensive culture system in 2013 and 2014

4.12.5. Statistical comparison of production for the year 2013 and 2014 in Bighay, Fakirhat fish farm

Production data of Bighay shrimp farm at Fakirhat was compared by paired t-test for the year of 2013 and 2014. The results showed that the pond fish production of 2013 (M = 0.06063 Mt, SD = 0.061) and 2014 (M = 0.06088 Mt, SD = 0.061) was not significantly different ($t(7)$ = 0.2904, p= .780).

4.13. Assessment of production differences in the ponds of three Upazila

The using one way ANOVA statistics, it was evident thate there was no significant differences between the means of production of ponds from each Upazilla in year 2013 and 2014 (Mongla F= 1.44, p>.05; Rampal F=1.47, p>.05 and Fakirhat f= 1.55, p>.05). Considering the average production avlues from ponds of each upazila per year has shown no differences (Mongla fish ponds, F= 1.64, p=0.203 in 2013; F=1.72, p=0.186 in 2014; Rampal fish ponds, F=1.76, p=0.178 in 2013; F= 1.68, p=0.195 in

2014; and for Fakirhat shrimp ponds, F= 1.81, p=0.167 in 2013; F=1.80, p= 0-169 in 2014).

This it is evident that though the production is less, but the culture practices by the farmers are uniques to produce fsh of similar quantity. Thus, by improving the inputs the production can be improved to next level.

Discussion

The present problem in shrimp culture is concentrated with several issues. They can be broadly categorized as physical, biological, environmental and social issues.

Physically the farm structure and water circulation were identified as major constraints. Similar observation were made by Afroz and Amal (2013). Diseases also be the pior issues (Alam et al. 2007; Akber et al. 2017,Alam, 2007). However, the prospect of muti species use is important for sustainability (Ali et al., 2000, Anon1994). The water quality issue also be the crital for shrimp culture (Boyd, 1995; Chandra and Das, 2013), However, the climatic factor or weather may influence the salinity of the shrimp ghers (DoF, 2007; Shelton 2014; Tucker et al., 2014; World Bank 2002). Proper technology is another issue to cover. The over stock use of PL led to high mortality and demad in the supply chain. The unforeseen issue can be solved by technological support from the government. The use of common water resources should be maintained by channel or water supply facilities provided by the governmental agencies (Nuruzzaman, 2002; Nuruzzaman et al, 2001). The natural PL and fish seed should be used in brood fish development instead of using in the farms. The localization and restrict of shrimp culture area should be demarkd by the governmental agencies (Khan and Azad, 2014; Khor, 1995; Mia, 2004).

The social aspect of shrimp culture is the conflict arises due to expansion of shrimp farms and the salinity intrution. They both impacted on the agriculture production and labour. The shrimp farms need less labour and, in many instances, change the productivity of the agriculture land. Mazid and Banu (2002) emphasized on the space allocation for shrimp culture expansion. Hasan et al. (2013) sketch an interesting issues on the agricultural land availability in Bangladesh. And the truth is the loss of crop land can be detremental for the job and nutritional security of the marginal poor.

Chapter 5. Summery

5.1. Summery

This study was carried out to identify the factors preventing the growing of shrimp in the Bagerhat district's Mongla, Rampal, and Fakirhat Upazila. To evaluate the production, four farms were selected from each upazila. Two crop seasons were taken into consideration, of which three farms implemented enhanced extensive culture systems and one underwent extensive culture systems. One of the upgraded extensive farmers has capabilities for exchanging water, while the other farms were inert. For all three upazilas, this study was conducted. Size of the farm, density of the stock, and other management practices such as liming, fertilizing, feeding, and controlling water quality were nearly the same in every region. The study was conducted to investigate the differences in production under different settings, that is, to determine the factors that are responsible for shrimp production. The culture period was February 2013 to December 2014.

In addition to the observations, one hundred and fifty shrimp farmers from each Upazila's seven villages were included as respondents.The one-year survey's goals were to learn about the socioeconomic standing of the participating shrimp farmers and identify potential recommendations for improving the farmers' standard of living. The focus group discussion (FGD), participatory rural appraisal (PRA), well-structured questionnaires, and interviews with shrimp cultivators were the survey methods used to obtain the data.

Age groups, religious affiliations, home types, fishers' educational backgrounds, family sizes, pond sizes, areas of ponds, cultured species, dyke cropping, household income, PL and fry sources, sanitation, agricultural land, monthly income and expenses, source of drinking water, money source, feeding, culture pattern, shrimp, prawn, and fin fish production, among other socioeconomic factors, were presented for the shrimp cultivators.

Due to their physical strength, the shrimp cultivators in the age group of 36 to 50 years had the largest percentage of cultivators—56.66% in Mongla, 46.66% in Rampal, and 50% in Fakirhat—according to the results of the current investigation. Only 45.33% of shrimp growers in Mongla, 94.66% in Rampal, and 54.66% in

Fakirhat were Muslims, despite the fact that Muslims made up the majority of respondents. Hindus made up the second-largest group of responders and were frequent shrimp farmers. In Mongla, they were discovered to be 286.66%, in Rampal, 5.33%, and in Fakirhat, 45.33%. Whereas no responders were identified in the Rampal and Fakirhat shrimp culture zones, 26% of the Christian population was found in Mongla.

The shrimp farmers who were included in the survey as respondents had a higher degree of education than illiteracy and were therefore literate. Merely 3.33% of the participants have completed their college degree in Mongla, 6.66% in Rampal, and 3.33% in Fakirhat. The majority of shrimp cultivators were concentrated in the mid-level, or classes six through ten, with 60% of them located in Mongla, 53.33% in Rampal, and 56.66% in Fakirhat, respectively.

The respondents in this study were shrimp producers with an annual income of at least 50,000 Taka and a maximum of one million Taka. Shrimp cultivators making between Taka 50,000 and 75,000 per year were more prevalent among respondents from Mongla (66.66%), Rampal (70%), and Fakirhat (56.66%), who were in the lowest income bracket.

Shrimp farmers with a minimum culture area of 0.1 hectares and a maximum culture area of more than 1 hectares were included in the survey as responders. It was shown that the majority of shrimp farmers had farms with a culture area of 0.50–1.0 hectares. It was discovered in 40 percent of Mongla, 36.66 percent in Rampal, and 34.66 percent in Fakirhat.

Dyke cropping was not used by any of the shrimp farmers that were included in the survey as responders. The salinity of the soil affects dye farming. Less dike cropping was observed in Mongla because to the region's high salinity. It was discovered that Mongla was the opposite of Fakirhat. Farmers who performed dyke cropping were discovered in Mongla in 8% of cases, Rampal in 28%, and Fakirhat in 97.33% of cases, respectively. Dyke cropping was not being used by the other farm owners.
Water salinity affects shrimp production. Since Mongla has higher salinity than

Rampal and Fakirhat, Mongla produced more shrimp than Rampal and Fakirhat combined. A minimum of 0.2 metric tons per hectare and a high exceeding 0.4 metric tons per hectare were observed. There were 56.66 percent of production exceeding 0.4 metric tons per hectare in Mongla, 54.66% in Rampal, and 4.66% in Fakirhat, respectively.

Fresh water availability affects the production of golda. The salinity in Mongla was found to be higher than in Rampal and Fakirhat; thus, Golda production was highest in Fakirhat, followed by Rampal and Mongla. The results showed that the highest was over 0.3 metric tons per hectare and the minimum was 0.1 metric tons per hectare. When production exceeded 0.3 metric tons per hectare, it was discovered in Mongla, Rampal, 16%, and Fakirhat, 64%, respectively.

The ability to produce fin fish is dependent on the availability of fresh water; however, certain species can be cultivated in brackish water. We found that Mongla had higher salinity than both Rampal and Fakirhat; thus, the output of fin fish was higher in Fakirhat than in Rampal or Mongla. A low of 0.6 metric tons per hectare and a maximum of 1 metric tons per hectare were observed. There was no one in Mongla, 1.33% in Rampal, and 45.33% in Fakirhat when the production exceeded one metric ton per hectare.

Every respondent follows essentially the same cultural pattern. Together, shrimp and finfish were a common practice for the shrimp producers who were included as respondents. In three Upazilas, not a single respondent was found to exclusively practice shrimp culture. When the first few months of the year arrived and the water's salinity began to rise, farmers would typically stock shrimp when saltwater first entered the farm. After two or three months, however, they would stock freshwater shrimp. Fin fish, including Persia, Tengra, Tilapia, Rui, Mrigel, Katla, Mirror carp, and others, were stocked after three to four months of tiger shrimp harvesting. All of the fish and shrimp were harvested at the conclusion of the year.

Bangladesh derives a significant portion of its export revenue from shrimp. The cultivation, processing, and export of shrimp already employ a greater number of people. In spite of certain benefits, shrimp farming has negative effects on the southwest part of the country's environment, people, and society. In order to improve shrimp cultivators' standard of living and increase their export revenue and productivity, government offices, non-governmental organizations, and local shrimp grower associations should offer training, credit, education, PL supplies, and other essential resources.

5.2. Challenges of shrimp cultivation

Shrimp farming faces certain challenges even though it is the nation's third-largest export business. The following issues are identified as the challenges for the sectors

- Insufficient instruction for ideal shrimp farming that could improve farmers' abilities and opportunities to for productive output
- The price structure is significantly and quickly changes. As a result of supply chain inconsistency led to unethical acts, like growers inject illegal substances into the shrimp to fulfill the weight limits
- The sector is severely hindered by the inadequate transportation infrastructure in the nation. Since bagda requires the shrimp to be carried from Cox's bazaar to Khulna, the issue is considerably more serious. Even the farm areas is not close to direct aviation facilities. Even after the production, the transportation from farm to shrimp-depot is difficult sometimes.
- The operating costs are high on the farms, high prices do not always translate into profits. There remains a very small profit after all left for the producers.
- There is no institutional financial support for the marginal farmers.
- The involvement of shrimp farmers in trading is not much apparent. The farmers involvement could address the overcome the issue of suppression by the non-shrimp farmer traders
- Disease free, quality, cost effective shrimp PL and shrimp-feed are prerequisite to boost up the production from present state
- Finally, a prerequisite for the sectoral success is the presence of governmental rules, regulations, and processes

Chapter 6. Conclusion and Recommendation

6.1. Conclusion

In case of foreign earnings of Bangladesh shrimp sector plays a vital role. A larger number of people are already involved with the production, processing and export of the shrimp. Despite of these advantages shrimp cultivation has serious impacts on the environment, society, people and other factors of the southwestern region of the country. On the other hand, though it is the third highest export earnings source of the country, there is no proper guidelines, rules and regulations for shrimp cultivation and exportation from the government. Therefore, the government should establish appropriate guidelines for choosing the site for shrimp farming. To eliminate the environmental impact of shrimp cultivation, further research should be done to determine whether it is wise to expand the cultivation of saltwater shrimp in low saltwater.

6.2. Recommendations

The blue gold shrimp is they key source of income in coastal Bangladesh. It is also an important commodity for export earnings. The recent trend of low production and income from the sector can be improved by adopting or addressing the followings

Shrimp culture issues

- An effective guideline for shrimp culture and exportation methods need to be available
- The control of illegal uses of antibiotics and other medicinal products
- Infrastructure should be developed for better communication and productivity
- Certified hatcheries with SPF (Specific Pathogen free) PL of shrimp should be make available for farmers.
- Integrated shrimp production with other agricultural product in certain seasons should be allowed to regain its fertility of land
- The shrimp culture value chain should be employed from the grass root level farmers

Policy issues

- Government of Bangladesh (GoB) should establish a regulatory authority to oversee all activities regarding shrimp cultivation.
- GoB should provide guideline and govern the land selection for salt water shrimp farming to avoid the conflict with agriculture. May also establish a monitoring cell to assess the ecological impact of shrimp culture.
- To enhance export, National Residue Control Plan (NRCP) should be maintained properly.
- The department of fisheries should provide the detection facilities and certification of drug residue in shrimp and other aquatic products.

- Training facilities should be make easier for all farmers so that they can produce more in less inputs.
- Bank loan with low interest should be introduced for the marginal shrimp farmers.
- GoB should take initiatives to reduce the price of shrimp feed.
- Research should be conducted to determine the possibility to improve farming of intensive-saltwater shrimp culture, which may reduce the environmental impact of shrimp farming.

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Appendices. 1. Statistical Analysis of production data

1. Joimoni. Mongla: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.6961
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals 0.00100
95% confidence interval of this difference: From -0.00481 to 0.00681
Intermediate values used in calculations:
t = 0.4070
df = 7
standard error of difference = 0.002
Data summary:

Group	Group One	Group Two
Mean	0.13450	0.13350
SD	0.12488	0.12948
SEM	0.04415	0.04578
N	8	8

2. Makordon, Mongla: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.8770
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals -0.00163
95% confidence interval of this difference: From -0.02556 to 0.02231
Intermediate values used in calculations:
t = 0.1606
df = 7
standard error of difference = 0.010
Data summary:

Group	Group One	Group Two
Mean	0.12838	0.13000
SD	0.12187	0.10270
SEM	0.04309	0.03631
N	8	8

3. Mithakhali, Mongla: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.1546
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals -0.00200
95% confidence interval of this difference: From -0.00496 to 0.00096
Intermediate values used in calculations:
t = 1.5954
df = 7
standard error of difference = 0.001
Data summary:

Group	Group One	Group Two
Mean	0.05775	0.05975
SD	0.05154	0.05356
SEM	0.01822	0.01894
N	8	8

4. Chandpai, Mongla: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.3159
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals -0.00100
95% confidence interval of this difference: From -0.00319 to 0.00119
Intermediate values used in calculations:
t = 1.0801
df = 7
standard error of difference = 0.001
Data summary:

Group	**Group One**	**Group Two**
Mean	0.05675	0.05775
SD	0.05278	0.05415
SEM	0.01866	0.01914
N	8	8

5. Rajnagar, Rampal: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.2012
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals 0.00263
95% confidence interval of this difference: From -0.00177 to 0.00702
Intermediate values used in calculations:
t = 1.4108
df = 7
standard error of difference = 0.002
Data summary:

Group	Group One	Group Two
Mean	0.12613	0.12350
SD	0.10300	0.10078
SEM	0.03642	0.03563
N	8	8

6. Gauromva, Rampal: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.1857
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals 0.00200
95% confidence interval of this difference: From -0.00122 to 0.00522
Intermediate values used in calculations:
t = 1.4676
df = 7
standard error of difference = 0.001

Data summary:

Group	Group One	Group Two
Mean	0.12038	0.11838
SD	0.09723	0.09591
SEM	0.03438	0.03391
N	8	8

7. Jhanjhania, Rampal : Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.4015
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals -0.00075
95% confidence interval of this difference: From -0.00274 to 0.00124
Intermediate values used in calculations:
t = 0.8930
df = 7
standard error of difference = 0.001
Data summary:

Group	Group One	Group Two
Mean	0.05838	0.05913
SD	0.05240	0.05122
SEM	0.01853	0.01811
N	8	8

8. Foyla, Rampal : Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.4423
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals 0.00038
95% confidence interval of this difference: From -0.00071 to 0.00146
Intermediate values used in calculations:
t = 0.8143
df = 7
standard error of difference = 0.000

Data summary:

Group	Group One	Group Two
Mean	0.05813	0.05775
SD	0.05377	0.05445
SEM	0.01901	0.01925
N	8	8

9. Tekatia, Fakirhat: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.1443
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals -0.07725
95% confidence interval of this difference: From -0.18839 to 0.03389
Intermediate values used in calculations:
t = 1.6435
df = 7
standard error of difference = 0.047

Data summary:

Group	Group One	Group Two
Mean	0.13288	0.21013
SD	0.12975	0.25737
SEM	0.04587	0.09099
N	8	8

10. Shattola, Fakirhat: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.1751
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals 0.07425
95% confidence interval of this difference: From -0.04211 to 0.19061
Intermediate values used in calculations:
t = 1.5089
df = 7
standard error of difference = 0.049

Data summary:

Group	Group One	Group Two
Mean	0.21363	0.13937
SD	0.26411	0.13035
SEM	0.09338	0.04608
N	8	8

11. Diapara, Fakirhat: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.0009
By conventional criteria, this difference is considered to be extremely statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals -0.00225
95% confidence interval of this difference: From -0.00322 to -0.00128
Intermediate values used in calculations:
t = 5.4628
df = 7
standard error of difference = 0.000

Data summary:

Group	Group One	Group Two
Mean	0.06000	0.06225
SD	0.06079	0.06110
SEM	0.02149	0.02160
N	8	8

12. Bighay, Fakirhat: Paired *t* test results

P value and statistical significance:
The two-tailed P value equals 0.7799
By conventional criteria, this difference is considered to be not statistically significant.
Confidence interval:
The mean of Group One minus Group Two equals -0.00025
95% confidence interval of this difference: From -0.00229 to 0.00179
Intermediate values used in calculations:
t = 0.2904
df = 7
standard error of difference = 0.001

Data summary:

Group	Group One	Group Two
Mean	0.06063	0.06088
SD	0.06189	0.06061
SEM	0.02188	0.02143
N	8	8

13. ANOVA of production at Mongla shrimp farms in 2013 (Tables 1-4)

Analysis of Variance Results
F-statistic value = 1.63933
P-value = 0.20273

Data Summary

Groups	N	Mean	Std. Dev.	Std. Error
Group 1	8	0.1345	0.1249	0.0442
Group 2	8	0.1284	0.1219	0.0431
Group 3	8	0.0578	0.0515	0.0182
Group 4	8	0.0568	0.0528	0.0187

ANOVA Summary

Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	3	0.0441	0.0147	1.6393	0.2027
Within Groups	28	0.2513	0.009		
Total:	31	0.2954			

14. ANOVA of production at Mongla shrimp farms in 2014 (Tables 1-4)

Analysis of Variance Results
F-statistic value = 1.71667
P-value = 0.18629

Data Summary

Groups	N	Mean	Std. Dev.	Std. Error
Group 1	8	0.1335	0.1295	0.0458
Group 2	8	0.13	0.1027	0.0363
Group 3	8	0.0598	0.0536	0.0189
Group 4	8	0.0578	0.0541	0.0191

ANOVA Summary

Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	3	0.0426	0.0142	1.7167	0.1863
Within Groups	28	0.2318	0.0083		
Total:	31	0.2745			

15. ANOVA of production at Rampal shrimp farms in 2013 (Table 5-8)

Analysis of Variance Results

F-statistic value = 1.76053
P-value = 0.17758

Data Summary

Groups	N	Mean	**Std. Dev.**	**Std. Error**
Group 1	8	0.1261	0.103	0.0364
Group 2	8	0.1204	0.0972	0.0344
Group 3	8	0.0584	0.0524	0.0185
Group 4	8	0.0581	0.0538	0.019

ANOVA Summary

Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	3	0.0339	0.0113	1.7605	0.1776
Within Groups	28	0.1799	0.0064		
Total:	31	0.2138			

16. ANOVA of production at Rampal shrimp farms in 2014 (Table 5-8)

Analysis of Variance Results
F-statistic value = 1.67599
P-value = 0.19476

Data Summary

Groups	N	Mean	Std. Dev.	Std. Error
Group 1	8	0.1235	0.1008	0.0356
Group 2	8	0.1184	0.0959	0.0339
Group 3	8	0.0591	0.0512	0.0181
Group 4	8	0.0578	0.0545	0.0193

ANOVA Summary

Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value

Between Groups	3	0.0314	0.0105	1.676	0.1948
Within Groups	28	0.1746	0.0062		
Total:	31	0.206			

17. ANOVA of production at Fakirhat shrimp farms in 2013 (Table 9-12)

Analysis of Variance Results
F-statistic value = 1.81479
P-value = 0.16737

Data Summary

Groups	N	Mean	**Std. Dev.**	**Std. Error**
Group 1	8	0.1329	0.1298	0.0459
Group 2	8	0.2136	0.2641	0.0934
Group 3	8	0.06	0.0608	0.0215
Group 4	8	0.0606	0.0619	0.0219

ANOVA Summary

Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	3	0.1281	0.0427	1.8148	0.1674
Within Groups	28	0.6589	0.0235		
Total:	31	0.787			

17. ANOVA of production at Fakirhat shrimp farms in 2014 (Table 9-12)

Analysis of Variance Results
F-statistic value = 1.80093
P-value = 0.16992

Data Summary

Groups	N	Mean	**Std. Dev.**	**Std. Error**
Group 1	8	0.2101	0.2574	0.091
Group 2	8	0.1394	0.1303	0.0461
Group 3	8	0.0623	0.0611	0.0216

Group 4	8	0.0609	0.0606	0.0214	

ANOVA Summary

Source	Degrees of Freedom DF	Sum of Squares SS	Mean Square MS	F-Stat	P-Value
Between Groups	3	0.1224	0.0408	1.8009	0.1699
Within Groups	28	0.6345	0.0227		
Total:	31	0.7569			

18. ANOVA on the production efficiency of Mongla shrimp farms in 2013 & 2014

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	7	0.08689	0.01241	1.4392	0.2083
Error (within groups)	56	0.483	0.008625		
Total	63	0.5699	0.009046		

One Way ANOVA test, using F distribution df(7,56) (right tailed)

1. H_0 hypothesis
Since p-value > α, H_0 is accepted.
The averages of all groups assumed to be equal.
In other words, the difference between the sample averages of all groups is not big enough to be statistically significant.

2. P-value
p-value equals 0.208253, [p(x ≤ F) = 0.791747]. It means that if we would reject H_0, the chance of type1 error (rejecting a correct H_0) would be too high: 0.2083 (20.83%)
The bigger the p-value the stronger it supports H_0

3. The statistics
The test statistic F equals 1.439232, which is in the 95% region of acceptance: [0 : 2.1782]

4. Effect size
The observed effect size f is large (0.42). That indicates that the magnitude of the

difference between the averages is large.
The η^2 equals 0.15. It means that the group explains 15.2% of the variance from the average (similar to R^2 in the linear regression)

5. Tukey HSD / Tukey Kramer
There is no significant difference between the means of any pair.

19. ANOVA on the production efficiency of Rampal shrimp farms in 2013 & 2014

Source	**DF**	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	7	0.06531	0.00933	1.4739	0.1954
Error (within groups)	56	0.3545	0.00633		
Total	63	0.4198	0.006664		

One Way ANOVA test, using F distribution df(7,56) (right tailed)

1. H_0 hypothesis
Since p-value > α, H_0 is accepted.
The averages of all groups assumed to be equal.
In other words, the difference between the sample averages of all groups is not big enough to be statistically significant.

2. P-value
p-value equals 0.195419, [p(x ≤ F) = 0.804581]. It means that if we would reject H_0, the chance of type1 error (rejecting a correct H_0) would be too high: 0.1954 (19.54%)
The bigger the p-value the stronger it supports H_0
3. The statistics
The test statistic F equals 1.473911, which is in the 95% region of acceptance: [0 : 2.1782]

4. Effect size
The observed effect size f is large (0.43). That indicates that the magnitude of the difference between the averages is large.
The η^2 equals 0.16. It means that the group explains 15.6% of the variance from the average (similar to R^2 in the linear regression)

5. Tukey HSD / Tukey Kramer
There is no significant difference between the means of any pair

20. ANOVA on the production efficiency of Fakirhat shrimp farms in 2013 & 2014

Source	DF	Sum of Square	Mean Square	F Statistic	P-value
Groups (between groups)	7	0.2507	0.03581	1.5506	0.1695
Error (within groups)	56	1.2933	0.02309		
Total	63	1.5439	0.02451		

One Way ANOVA test, using F distribution df(7,56) (right tailed)

1. H_0 hypothesis
Since p-value > α, H_0 is accepted.
The averages of all groups assumed to be equal.
In other words, the difference between the sample averages of all groups is not big enough to be statistically significant.

2. P-value
p-value equals 0.169485, [p(x ≤ F) = 0.830515]. It means that if we would reject H_0, the chance of type1 error (rejecting a correct H_0) would be too high: 0.1695 (16.95%)
The bigger the p-value the stronger it supports H_0

3. The statistics
The test statistic F equals 1.550644, which is in the 95% region of acceptance: [0 : 2.1782]

4. Effect size
The observed effect size f is large (0.44). That indicates that the magnitude of the difference between the averages is large.
The η^2 equals 0.16. It means that the group explains 16.2% of the variance from the average (similar to R^2 in the linear regression)

5. Tukey HSD / Tukey Kramer
There is no significant difference between the means of any pair.