Chapter 1

Introduction

1.1 The Context

The economy of human activity continuously consumes natural resources. It is derived from the environment. Most of them are essential for our survival while others are used for satisfying our wants. Learning more about natural resources allows for a sustainable method to manage resources and makes sure that they are made available for future generations. The goal of natural resource management is to develop an efficient economy in the long run. But with the passage of time, natural resources including fishery resources get depleted due to over-extraction or overuse, which causes environmental problems such as air and water pollution, land erosion, or destruction of ecosystems and a decrease in biodiversity. The excessive extraction and use of natural resources along with other human activities may adversely interfere with biodiversity, that is, the existence of a variety of organisms that live on the earth. Diminishing biodiversity has a substantial human cost because biological species including a wide variety of fish species and natural ecosystems are crucial resources without which life on Earth ceases to exist.

With respect to renewability, natural resources are divided into two kinds- a) resources with the capacity for self-generation and b) resources without the capacity for self-generation. The former type is known as renewable resources and the latter is known as non-renewable resources. For renewable resources to survive over time, the maintenance of a critical minimum stock is an urgent necessity. If their stock levels heavily dwindle, they could not completely replenish themselves such as fishery, forestry, crop cultivation land, groundwater irrigation, grazing ground, etc. On the contrary, non-renewable resources are formed over a long geological period. Their rate of regeneration is too slow, so they cannot replenish themselves on an economically relevant time scale once they get depleted. A large number of people depend on existing natural resources for their subsistence. This put them under the threat of deterioration and degradation and even extinction. In recent times, we began to use fertilizers and pesticides to further boost the production of food from the same amount of land. However, we now realize that all this has led to several unwanted environmental changes. Industrial growth, urbanization, and the enormous increase in the use of consumer goods have all put further stress on the environment. They create great quantities of solid

waste. Pollution of air, water, and soil has begun to seriously affect human health. (Natural Resources, 2004). The degradation of renewable natural resources not only threatens the economic prospects of future generations but the livelihood of the current users as well. However, human society possesses capacities both for conservation and for the destruction of the renewable base (Clark, 1973). Thus both types of resources are capable of total exhaustion (smith, 1968).

Some people think that fish farming is a new phenomenon, actually, it has been around thousands of years ago, with the first known monograph on the subject appearing in China in the fifth century BC with the publication of the ‗Treatise on Fish Culture' by Fan Li in 473 BC. (A.G.J. Tacon, Second Edition in Encyclopedia of Food Sciences and Nutrition (2003).

Today, fish provides more than one billion poor people with most of their daily animal protein. Fish provides nutrients and micronutrients that are essential to cognitive and physical development, especially in children, and are an important part of a healthy diet. It not only has improved food and nutrition security but has also increased income, improves livelihood, promotes economic growth, and protects our environment and natural resources. Fish are today being over-harvested until the catch has become a fraction of the original resource and the fish are incapable of breeding successfully to replenish the population (Natural Resources, 2004).

Since fishing is one of the oldest ways to make a living, human civilization has mostly developed on riverbanks since time immemorial. Gradually, it has created an occupation for countless individuals called "fishermen". In West Bengal, vast areas of wetlands comprising rivers, canals, beels, bheries, reservoirs, ponds, falls, estuaries, and the coastline of the Bay of Bengal have made the state a torch bearer in fishery development.

In India, the annals of Fisheries have their origin in the Koutilya's "Arthasastra" (320BC) where there is an indication of fish culture in reservoirs. In modern times, H.S Thomas, I.C.S. (1871-1947) submitted a memorandum to the Famine Commission during the British period advocating for the development of fisheries as one of the measures to generate employment and fight famine.

Since the beginning of the eighties of the last century, Governments, both at the centre and the state paid serious attention to the fisheries sector and took some positive steps including

making new legislation for its development. Since the nineties in the last century, the Govt. of West Bengal undertook a number of projects and programs which are being run by the Fishery Dept., Govt. of West Bengal, and by different bodies under the dept. with financial assistance from the Center and the World Bank aiming at the development of the fishery industry as well as the all-around development of the fishermen community who are still the poorest of the poor in our society. Very recently, the Central Govt. has embarked on an ambitious program, called ―Blue Revolution Strategy‖ to make the country self-sufficient in the production of fish.

With the advancement of science and technology, the fishery sector has developed manufacturing facilities like ―pisciculture", ―shrimp culture", ―crab culture" and ―colour fish culture" etc. giving the scope to transform it into a ―Fishery Industry". It has vast potential in respect of employment generation, resource creation, and spreading commercial activities through wholesale and retail trade as well as export trade for earning foreign currencies. It has also given birth to a number of ancillary industries, mainly cottage and small-scale industrial units like food processing, dry fish preparation, cold storage, net and boat making, ice plant, fish feed and fish meal preparation, hatchery making, etc.

In spite of so many developments, the fishery industry in West Bengal seems to be plagued by many problems which are standing in the way of its further development. There is no denying the fact that despite problems, the fishery industry of West Bengal has tremendous potential for development. Therefore, a study of the problems and prospects of fishery development in West Bengal in general and of North Bengal, the most resourceful region, in particular, is of far-reaching importance to the economy and well-being of the people of the State.

1.2 Indian scenario

India is a maritime country and has a vast stretch of inland and marine water resources that are being utilized for capture and culture fisheries. The Indian fisheries sector has the unique identity that it is set in a unique and diverse set of ecosystems ranging from the pristine waters of the Himalayas to the sprawling Indian Ocean. This may be considered to be nature‘s best boon to India. The fisheries biodiversity of the country encompasses a wide field of physical and biological components that support the livelihoods of crores of people. Fisheries resources are set in different ecosystems. With the rising population and the

increasing demand for fish protein, the need for sustainable development of aquatic resources is now felt much more than ever before. To meet the convincing demands and to ensure a growth path that fulfills the requirements of today and leaves an equally better fishery for tomorrow, one has to manage this sector well.

Fisheries are regarded as a vital source of food, nutrition, employment, and income in India. This sector provides livelihoods to about 16 million fishers and fish farmers at the primary level and almost twice the number along the fishery value chain. Fish being an affordable and rich source of animal protein is one of the healthiest options to ease hunger and malnutrition. This sector has immense potential to increase income by more than double the fishers and fish farmers‘ incomes, as envisioned by the government. Commencing as a purely traditional activity, fisheries have now transformed into a profitable enterprise. The total fish production in India has increased from 7.54 lakh tonnes in 1950-51 to 95.79 lakh tonnes in 2013-14. The inland fish production has increased from 5.34 lakhs tonnes in 1950-51 to 34.43 lakhs tonnes in 2013-14 whereas the marine fish production has increased from 2.43 lakh tonnes in 1955-56 to 61.36 lakhs tonnes in 2013-14. The share of inland fish production has decreased from 71.04 percent in 1955-56 to 36.74 percent in 2012-13 but the share of marine fisheries has increased from 28.99 percent in 1950-51 to 64.06 percent in 2013-14. The sector has been one of the key contributors to foreign exchange earnings with India being one of the leading seafood exporting nations in the world. Marine exports stand at about 5 percent of the total exports of India and constitute 19.23 percent of agri-exports (2017-18). During 2018-19, the export of marine products stood at 13, 92, 559 metric tons and was valued at Rs.46, 589 crore (USD 6.73 billion). The rapid rise in the growth of seafood exports has been mainly due to a boom in brackish water aquaculture.

Fisheries being a state subject, the States play a pivotal role in fisheries governance. The role of the Central Government is to complement the former‘s efforts in this regard under the guiding principles of cooperative federalism. While inland Fisheries are fully managed by state governments, marine fisheries are a shared task between the central and coastal state/UT governments. Coastal States/UTs are accountable for the development, management, and regulation of fisheries in the sea waters inside the 12 nautical miles (22 km) territorial limit. The government of India is responsible for the development, management, and regulation of fisheries in the EEZ waters ahead of 12 nautical miles and up to 200 nautical miles (370 km). Therefore, it is crucial that the Center effectively manages and regulates this common

property resource for its sustainable and responsible utilisation in close collaboration with States.

1.3 West Bengal Scenario

The fishery constitutes an important type of natural resource of a country and it is defined to be a renewable natural resource having the capacity to regenerate stock in a time frame that is relevant for human exploitation. Hence its commercial production and harvesting can provide enormous scope for the economic development of the State on a sustainable basis. The development of fishery economic activities in different directions can lead to income and employment generation for the rural population on a significant scale. The state of West Bengal is the pioneer and leader in the production of fish and fish seed in India. With a very large body of inland water for capture and culture fisheries, West Bengal is better known for its considerable inland water fish production. By tradition, fish is an important part of the diet in West Bengal and the main role of the fisheries sector has been as a provider of food.

The share of West Bengal in India is approximately 13.84 percent of total fish production in India. It produced 1742 metric tons of fish production, of which 1557 metric tons is from inland fisheries and 185 metric tons is from marine fisheries in 2017-18 (Handbook of fisheries statistics, Government of West Bengal, 2017-18). West Bengal has a 17.49 percent share of inland fisheries and 5.16 percent of marine fisheries in India in 2017-18. The fish production of the inland fishery sector in West Bengal has increased from 340 metric tons in 1980-81 to 1534 metric tons in 2017-18. This region is rich in water resources. It has a total of 7.45 percent of the water resources of our country. The total impounded freshwater area available for the fishery sector is at present 3, 32,379 hectare including Beel and Baor. Freshwater fisheries cover about 80-85 percent of the total closed water system (Handbook of fisheries statistics, Government of West Bengal, 2017-18). The compound annual growth rate of production of fish in West Bengal has declined over the year from 5.02 percent in 1990-91 to 0.59 percent in 2017-18. There are about 3.2 million fishermen inhabitants out of 91.3 million human populations.

1.4 North Bengal Scenario

The fisheries sector constitutes an important component of the regional rural economy of North Bengal which encompasses eight northern districts of West Bengal. This region is a

significant producer of fish in the state of West Bengal. The sector provides an important source of livelihood opportunities for the rural population of this region. The North Bengal fishery is mainly comprised of Inland fishery resources. The pond fishery is the dominant form of fishery operation. The region is rich in water resources. The total water area available for the fishery sector is at present 41752 hectares. The fishery sector of the region registered 199277 metric tons of fish production in 2017-18, which is 12.8 percent of the total fish production in West Bengal during this period. It also produces 986 million tons of fish seed, which is 7.91 percent of total fish seed production in West Bengal in 2017-18. One significant phenomenon of the fishery sector in this region is the transfer of traditional cropland into pond fishery on a significant scale in some districts. This perhaps suggests that the region has immense potential for the development of inland fishing. Another important phenomenon witnessed in recent times is that the sector has been undergoing a transformation from traditional fishing activity to commercial fishing activity on a significant scale in the form of the proliferation of pisciculture. This is supposed to have an important bearing on the growth of fish production in this region in the near future. Being largely a labor-intensive activity, the growth promotion of fish production is expected to be accompanied by a significant additional employment generation in the labour-surplus rural economy of the region. This is supposed to uplift the socio-economic condition of a large chunk of the rural population of the region.

1.5 Problem Perspective and Statement of the Problem

North Bengal is blessed with abundant water resources. This vast quantity of water resources plays a vital role in supporting fishery activities in this region. In North Bengal, the dominant form of fishery is freshwater pond fishery. There are numerous natural and man-made ponds in this region, which provide suitable conditions for fish farming. A significant amount of rainfall during the monsoon season and suitable climatic conditions make the region conducive for freshwater pond fish farming. Freshwater pond fishery is widely practiced by both small-scale and commercial fish farmers in North Bengal. Various species of carp, including Rohu, Catla, Mrigal, and common carp, are commonly farmed in these ponds. Indigenous fish species and exotic varieties are also reared based on market demand and suitability to local conditions. This sector in this region plays a crucial role in supporting the local economy, providing livelihood opportunities for a large number of people, particularly

small-scale fishers and farmers. It contributes to food security, income generation, and rural development in the region.

The production of fish in North Bengal is primarily done through pond fish farming which has seen significant growth in recent years. It is no exaggeration to say that the pond fish farming operation is a growing industry in the region, with many people acquiring this entrepreneurial skill. These developments necessitate an examination of whether the growth of production of the pond fishery sector has been driven by bringing in more area under this segment of fishery alone or whether the achievement of such phenomenal growth in production is attributable solely to the improvement of resource use efficiency, or both factors are to be considered as contributory factors behind such changes.

Given the above background, it is absolutely necessary to make an analytical review of the productivity and efficiency performance of the pond fishery sector in the districts of North Bengal. The measurement of the technical efficiency of production along with the estimation of scale efficiency and the nature of returns to scale that emerges from the input and output relationship would help to understand better the production economics of this emerging sector. It is well worth reemphasizing that the measurement of the productive efficiency in fish production is an important issue since it gives pertinent information useful for making sound management decisions in resource allocation and for formulating policies for improvements of the institutional framework.

A second important area of inquiry is the investigation of the role of pond fish farmers in the adoption of modern techniques to improve productivity and efficiency. For this to happen, they need to acquire higher skills and efficiency with the passage of time to contribute positively to production. In light of this, it is essential to evaluate the significance of gradually improving worker skills for gaining production efficiency in this industry.

A third important aspect of the investigation is how far this sector would be able to provide the major source of employment and livelihood for the population of North Bengal. As this sector is still emerging over the last few decades, social welfare needs to be increased in terms of greater employment opportunities and livelihood security and this would be of immense significance for the people of this region. A related inquiry to be made is to find out what role changing occupational choice plays in meeting the objective of securing a decent livelihood.

Finally, the identification of major challenges and opportunities concerning inland fishing operation and the recommendation of effective measures for the sustainable development of inland fishery also constitute essential areas of research.

1.6. Review of Literature:

1.6.1 The International Context

The literature available in the international context has been arranged as under:

David Hallam and Fernando Machado (1996) evaluated the technical efficiency of Portuguese dairy farms using frontier production functions estimated from panel data. The results reveal that 70 percent of average efficiency was supported by both the GLS and Hausman- Taylor estimates. The empirical results tend to support the view of Ferro. et al. (1993) that bigger farms tend to be more efficient. Efficiency appears to be a positive correlation with the farm's size but is independent of the degree of specialization.

Kaspersky and Peter (1998) describe the dynamic nature of inland water bodies and the diversity of their aquatic fauna. Fisheries prosperity will not occur unless the management of the aquatic environment is improved and its benefits better shared. Even within the sector, more integrated approaches were being suggested in fisheries ecosystem management, which is a reasonable proxy for other integrated area management schemes in coastal, inland, and river basin bioregions processing, packing, and storing fish instead of increasing fish production is recommended to increase production efficiency in the research area.

M. A. Alam, K. M. Mostafizur Rahman, and M. A. Quddus (2005) in their studies, the Translog stochastic frontier cost function was estimated to determine the economic efficiency of fish production in Bangladesh. The economic inefficiency effect model was estimated to identify factors that influence simultaneously stochastic efficiency. The coefficients of age and experience were negative and significant in the stochastic frontier which meant that the cost of fish production decreased with the rise in age and experience of the farm operators. The sign of farm size was positive and significant in the inefficiency effect model, which meant that the large farmer was economically less efficient than the small farmer. The economic efficiency varied from 15 percent to 99 percent at an aggregate level, 96 percent to 98 percent in Mymensingh, and 63 percent to 99 percent in the Rangpur region. The mean economic efficiencies were 97 percent, 89 percent, and 71 percent for Mymensingh, Rangpur,

and all regions, respectively. There appeared to be 3 percent, 11 percent, and 29 percent economic inefficiencies for Mymensingh, Rangpur, and all regions, respectively. This study indicated that the cost of production could be reduced by 29 percent keeping the output constant at the aggregated level. For policy options, extension services should be made available for all fish farmers. Education should be another important priority of the government to develop the necessary human capital for sustainable growth of the fishery sector.

Nobuyuki Yagi (2008) has tried to establish the empirical link between production and subsidies in the fishery sectors. This paper was conducted to understand the nature and the magnitude of the effect caused by subsidies to fishery productions. The total volume of fishery production is directly influenced by the government's direct payment program but is inversely affected by the number of general services provided by the government for OECD Countries.

Stanley Wales Thosi Mvula (2009) identifies various factors that influence the choice of fishing location and carry out a profitability analysis of Chilimira and Gillnet in different fishing locations. Using a semi-structured questionnaire, a survey was administered to 99 Gillnet and 101 Chilimira fishers in Nankumba Peninsula in Mangochi District. The logit model was used to determine the factors influencing the choice of fishing location among the fishers. The study showed that 92.1 percent of Chilimira fishers are operating in offshore areas while 69.7 percent of Gillnet fishers are operating in inshore areas. Chilimira offshore fishers have higher daily average gross margins than their inshore counterparts and Gillnet fishers. However, they incurred more operating costs than the inshore Chilimira and Gillnet fishers. Furthermore, they find their fishing occupation more rewarding as evidenced by the higher returns to labour. The factors that influenced the fisher‘s choice of fishing location were the age of the fishermen, the type of fishing vessel and gear, possession of a motor sail engine, and access to information about the previous day‘s catch rates. Finally, the study concluded that artisanal fishers in Malawi use different criteria in deciding ―where to fish”. The criterion involves a complex interaction of biological, technological, personal, and economic factors and time. However, the resource-constrained artisanal fisher will need support to enable him to develop offshore fishery resources. Therefore the study recommends that appropriate fishery development interventions by the government and other stakeholders

must adapt to the economics and lifestyles driving the artisanal fishers to fish in particular locations and therefore, build on this foundation to improve the existing fishing technologies.

Lundvall and Battese (2000) establish a diverse relationship between farm size and technical inefficiency in developing countries using the frontier production function. But according to Iinuma et al. (1999) and Dey et al. (2000), the coefficient of land in the study is estimated to be significantly positive, implying that fish farms that operate small ponds are technically less inefficient than farms with large ponds. The results revealed that the coefficient estimated for the gender dummy and pond type dummy is significantly negative but the coefficient of education is surprisingly positive.

Edward E. Onumah et al. (2010) have examined the productivity of hired and family labour and various determinant of the technical efficiency of fish farms in Ghana. The results showed that various factors such as family labour, hired labour, feed, seed, land, and extension visit have a significant effect on fish farm production. The results have shown that all the inputs are positive, indicating that various factors have a direct relationship with fish production. The output elasticity with respect to seed is very small and insignificant.

Shaowei Shen, Zuiyi Shen, and BingXu (2013) have considered empirical studies on the fishery production efficiency of Zhoushan's new district based on the data envelopment analysis (DEA)model of three–stage. The results show that environmental variables and random factors do have a significant effect on the fishery production of Zhoushan. The increase in urbanization level and the average year of population education are the positive factors to improve fishery production; fishermen's per capita income and fishery subsidies provided by the government are the unfavorable factors in the improvement of fishery production efficiency. After eliminating the influence of environmental variables and random factors, we get a comparatively real efficiency of fishery production in Zhoushan's new district.

Christian Crentsil and Essilfie (2014) have adopted the single-stage modeling technique and the results revealed that about 71 percent of the sample were members of FFA, while more (89.52 percent) of them had contacts with extension agents. The main objective of the paper was to examine the level and factors affecting the technical efficiency of smallholder fish production in Ghana. The results also showed that the labour employed the number of

fingerlings stocked, and the quantity of feed used have direct and significant determinants of technical efficiency among smallholder fish farmers.

Samsun, Vedat Ceyhan, and Hanife Gene (2014) have identified that Japan has experienced dramatic declines in fish stocks sourced by overcapacity, and thus, there has been a decline in the economic benefits of fishermen, industries, and regions that rely on fisheries for their support. In Samsun Province, Turkey, the study evaluated productive efficiency measures for large-scale modern commercial fishermen. Data envelopment analysis (DEA) was used to analyse productive efficiency measures. 55 trawlers and 65 fishermen who prefer to use trawlers together with seine fishing were interviewed in the year 2007–2008 production periods. The research results showed that the mean economic efficiency of trawlers and the fishermen preferring to use trawlers together with seine fishing were 0.535 and 0.667, respectively. The primary source of economic inefficiency for trawlers was allocative inefficiency, while that of mixed fishermen was technical inefficiency in Samsun. Decomposition of the technical efficiency showed that pure technical efficiency was the key cause of the technical inefficiency for both trawlers and mixed fishermen. The majority of the fishermen in both fishing types exhibited increasing return to scale. The research findings revealed that the basic source of inefficiency was overcapacity problems sourced by market failures and restrictions on season length in the research area. The policy measures aimed at increasing training and extension programs, helping fishermen improve their technical information, eliminating inefficiency sourced by overcapacity, sustainable use of the fish stocks, and encouraging fishermen to obtain higher value-added from fish and other sea products via processing, packing, and storing fish instead of increasing fish production are suggested to increase production efficiency in the research area.

K.C Igwe and J.U Mgbaja (2014) have focused on the evaluation of pond fish production in Umuahia South L.G.A of Abia state. The study determines the cost, returns, and hence profitability in the study area. Data were obtained from 40 pond fish farmers using a random sampling procedure. The results showed that there is a significant relationship between total revenue and farm size, feed cost, labour cost, and cost of fingerlings. Increased fish production would guarantee the required protein among the poor household in the study area.

Sadiq et al. (2015) have examined the resource-use efficiency of small-scale fish production in Niger State, Nigeria. Multi-stage sampling technique was used by selecting 65 fish farmers, which were obtained from the Agricultural Development Project (ADP) of Bosso

and Chanchaga respectively. Regression results indicate that feeds, fingerlings, water, depreciation on capital items, and labours were significant determinants of output in fish production. This study has shown that fish farmers were inefficient in the application of productive resources. Also, low output prices, Imperfect conditions of inputs markets hampered the efficient utilisation of inputs products.

Reza Mahmoudi et al. (2020) in their paper, ' The origin, development and future directions of data envelopment analysis approach in transportation system', and the application of data envelopment analysis (DEA) in transportation problems have gained considerable attention. First, by classifying the 40 most cited papers from 2007 to 2018, the DEA model has been widely used in evaluating the performance of transport systems. 3 selected models have been introduced briefly- CCR (Charles, Coopes & Rhodes), BCC (Banker, Charles & Cooper), and SBM (slacks-based measure) which have been popularly used in the literature. The content of this paper includes ' Number of published papers during the time', ' target journal', 'countries', 'keywords frequency', and _Most cited papers', DEA helps the decision makers in evaluating TSs for policy maker and also useful in case of transportation, especially development, and eco-design.

Shaoweishen et al. (2020) have used the three-stage DEA model to analyse fishery production efficiency. The results reveal that correlations between the comprehensive technical efficiency of each country and the per capita output of all fisheries have increased significantly. The application of the three-stage DEA model is more reasonable and precise than the traditional DEA model in the measurement of fishery production. The results showed that the average technical efficiency of each country has increased from 0.626 to 0.628, the average scale efficiency has increased from 0.771 to 0.778 and the average of pure technical efficiency has dropped from 0.828 to 0.821 after eliminating the influence of random variables and environmental factors.

Dr. K. Krishnamurthy and Mr. T. Sasikumar (2020) investigate the efficiency of the 12 selected MFIs using Data Envelopment Analysis (DEA). This paper examines the performance of the top MFIs mainly through outreach indicators of productivity and financial performance. Five institutions like BWDA Finance, SKS, Spandana, Suryoday, etc. were found to be the most efficient institutes in DEA-CCR Model. Additionally, two more institutes were deemed to be efficient as their total efficiency scores were higher than the mean efficiency scores of all the sample units.

1.6.2 The Indian Context

S. Saxena (1983) pointed out that lack of detailed data on resources, their utilisation, production levels, and marketing practices have affected adversely the development of inland fish cultivation. He suggested that steps should be taken to improve credit arrangements for the farmers.

John Kurien and A. J Vijayan (1995) pointed out that a vital feature of small-scale fishing communities in developing countries is community-evolved mechanisms to ensure that the resources, livelihood opportunities, and revenues from the common property fishery are spread as widely as possible in the entire community. For almost half a century, this article examines the case of an income-spreading mechanism that has been practiced in the coastal encircling net fishery of Kerala. It shows how a combination of unsuitable technology choices coming in the wake of free market policies, and a now increasingly common pattern of state patronage of rural producers, often combine to produce open-access conditions in common property resources and thus put eminently desirable communitarian systems of sharing and caring under great strain.

Mahesh .V. Joshy (1996) explains the importance of fisheries in our national economy. He also analyses the impact of mechanisation on fish catchment, income, export, the standard of living, and employment opportunities in the marine fishing sector in a wider aspect.

Rajan (2000) assesses the present socio-economic conditions of the traditional fishermen community by examining the intervention effect of MATSYAFED in the traditional fishing economy of the state. The study also attempts to examine the popularity and effectiveness of cooperativization, input supply, market intervention, and extension. The study highlights the importance of the fishing sector in the state economy and the evolution and emergence of the traditional fishing community.

M. Suresh (2012) in his Thesis Paper –Export Potential of Marine Products And Its Impact on Eradication of Poverty in Andaman Islands (A Study with Special Reference to Tuna Fish Variety)" has set a brief introduction about international trade and its theories, World and Indian history on import-export, tuna export and its opportunities in the international market and steps to export fish from India.

Bijayalakshmi Devi Nongmaithem and Ajit Kumar Ngangbam (2014) pointed out that the Socioeconomic conditions of the fishers in India are very low. Fishers generally have pursued less education and live under inappropriate housing conditions. With a very low income from fishing, fishers supported a large member of the family which compels the fishers to burrow credits to fulfill their basic needs. The incomes of the fishers were very low and remained circulated inside the vicious circle of poverty. India is a country with multiplicity in culture and this cultural diversity was reflected in their fishing activities too. Training programs and scientific orientations are availed in most places in India. Therefore, appropriate fishery management policies, effective input supply, and technical and social support may progress the livelihood of the fishers which will eventually enhance the overall fisheries productivity of India.

Monalisha Chakraborty (2016) has tried to clarify that Orissa is a maritime state, having 589 marine fishing villages and 3289 inland fishing villages. This paper mostly aims to show the socio-economic condition of the fisherman of Bali Nolia Sahi village, Puri. The results show that the socio-economic conditions of the fisherman of Bali Nolia Sahi were not excellent. Their housing conditions were not too bad, but in terms of fishing, they don‘t get much aid from the Government. They lack the basic supplies for their fishing which depressed the development of fishing in the State.

Dr. R. Santha Kumari (2017) pointed out that fish play a crucial role in the food security of the country and fish is the key source of protein in the whole world. Protein deficiency leads to persistent diseases like anemia which is a central problem in developing countries like India. In addition to the supplementation of protein, fish also supplies necessary amino acids, fatty acids, and water-soluble and soluble vitamins. Fish meat is a vital constituent of human and animal nutrition. The demand for fish is endlessly rising based on the nutritional value and increasing population of the world. The Food and Agricultural Organisation (FAO) has estimated the demand for fish as 180 million tons by 2015 from the existing 145 million tons. An increase in fish production is possible by appropriate management of water bodies is the major concept of ―BLUE REVOLUTION".

Subhashree Banerjee (2018) has done a case study of Vetka village in the Bhitarkanika Wildlife Sanctuary to demonstrate how resident households practice occupational diversity to overcome the loss of their prime occupation of fishing and depend on forest products, both debarred by the forest department in the eco-sensitive zone.

Chittaranjan Najak and Chinmaya Ranjan Kumar (2019) examined the subtleties of crop diversification in Odisha across 30 districts. Crop diversification plays a vital role to promote agricultural development. The analysis carried out from 1993-94 to 2012-13 indicates an unevenness in crop diversification. The analysis reveals that greater use of high-yielding crops and access to irrigation resulted in crop concentration whereas rural roads and income lead to crop diversification.

Sourya Acharya et al. (2019) have evaluated the efficiency of 'panel discussion' as a teaching and learning tool for undergraduates in the subject of Medicine. One hundred students of final year MBBS were separated into 2 groups. In the comparison of the pre-test and post-test in the study group, there was a significant improvement in the post-test. The implementation of the panel group discussion contributed to a better impact on students' self-confidence, learning, and overall understanding of the subject.

1.6.3 The West Bengal Context

Jaydev Misra and Sib Ranjan Misra (2014) have pointed out the concept of meta-frontier data envelopment analysis (DEA) to examine whether there is any systematic difference in the technical efficiency (TE) of fish farms of diverse size classes categorized on various socio-economic situations. Efforts have also been made to identify the influence of those characteristics on TE scores using regression analysis. The study has shown that the overall mean TE is 62.8 percent, which indicates that on average, the realised fish output can be raised by 37 percent in the state with the existing technology and resources. Ample variations in TE scores have been found when farms were categorised on the basis of size, region, ownership pattern, or proprietorship. The farm experience, ownership, and sole proprietorship are the most important determinants of TE. However, pond size and education have not depicted any significant relationship with TE. In order to improve the efficiency of fish culture, location-specific should be adopted in development strategies, long-term leasing policies, and participatory extension should support West Bengal.

Sanchita Saha (2016) in her Ph.D. thesis titled –Economics of Fishery and Livelihood: A Study in the coastal regions of West Bengal" made an attempt to investigate the Economics of Fishery and Livelihood in the Coastal belt of West Bengal. For this, she has emphasised the issue of sustainability of the fisheries sector in the coastal belt of West Bengal. This issue has gained importance because of the fact that the fishery management practices in India have

experienced different kinds of obstacles in different periods of time in various parts of the country. This issue has also strong implications for the livelihood of the stakeholders associated with fisheries.

Md. Ekramuddin (2017) has conducted a survey in 10 significant villages of Birbhum, an economically backward district of West Bengal to analyse the impact of small-scale fish farming in the rural socio-economic aspect. Five respondents from each village were interviewed providing a set of questionnaires to obtain a clear view of demography, social and financial status, the nature of the fishery, and the economy that is directly related to the fishery. It reveals that the majority of fish farmers are males and most are not educated beyond class 10 levels. The respondents have an average household size ranging between 3-6 persons. The result of descriptive analysis and test of significance showed that there is a significant impact of small-scale fishery enterprise on the rural economy.

1.7 Objectives of the Study

a) To trace the growth and consolidation of inland fishery in India vis-à-vis West Bengal.

b) To find out whether the region of North Bengal has any potential for the development of inland fishing activities, especially pond fish farming.

c) To provide an overview of the current regional fish marketing scenario in North Bengal.

d) To make an appraisal of the efficiency of the existing fish marketing system encompassing the districts using standard marketing efficiency metrics.

e) To carry out a supply−demand analysis of fish in order to assess the potential demand and supply gaps in the different districts of North Bengal.

f) To estimate the technical efficiency of the pond fishery using the parametric stochastic frontier approach and the non-parametric DEA approach.

g) To compare the relative impacts of different productive inputs on fish output and productivity using stochastic frontier regression output.

h) To estimate the technical efficiency and scale efficiency of fish production by applying suitable non-parametric optimization methods such as DEA and to identify the sources causing economic inefficiency to pond fish farming.

i) To identify the nature of a return to scale (time-invariant) and its impact on the cost economics of pond fishery.

1.8 Research Questions of the Study

The research questions have been framed based on the objectives mentioned above.

a) How much have the inland fisheries in West Bengal grown and consolidated compared to India?

b) Does the region of North Bengal have immense potential to grow its inland fishing industry?

c) What is the state of fish marketing structure at present in North Bengal?

d) What is the reason for the occurrence of fish supply-demand imbalance in this reason?

e) Can the fish marketing system of the region be considered efficient in terms of established benchmarks for marketing efficiency?

f) Does the pond fishery perform efficiently in terms of technical efficiency?

g) Is the pond fish farming enterprise utilising its productive resources to its fullest potential without having slacks?

h) Does the attainment of resource use efficiency region-specific or region-neutral?

h) What is the type of returns to scale that comes out from the observed relationship between input and output at the pond level?

1.9 Hypotheses of the Study

a) Inland fishing operations, especially pond fish farming, have stagnated over time in North Bengal.

b) There are wide variations in fish market infrastructure across the districts.

c) The efficiency of the fish marketing system of the region is relatively low by virtue of established benchmarks for marketing efficiency.

d) The demand for fish in North Bengal is entirely met through local production without depending on the import of fish.

e) The pond fish farmers of the region are neither technically efficient nor scale efficient.

f) The attainment of resource use efficiency is region-specific rather than region-neutral.

g) There are a sizable number of fish farms operating under constant or decreasing cost conditions.

1.10 Data, Variables, and Sample Method

This study is both analytical and exploratory work based on both primary and secondary data. The collection of primary data has been done through extensive field surveys using a structured questionnaire. The survey was administered among the pond fish farmers in eight villages under four development blocks located in the districts of Uttar Dinajpur and Dakshin Dinajpur, respectively, in the North Bengal region. The method of sample drawing for the collection of data is designed to be cluster sampling where clusters consist of sample study locations of pond fish farmers. The study also makes use of secondary data to analyse the state of fishery development in different directions, such as the production of fish and fish seed, export, import, marketing, etc., in North Bengal in relation to India and the West Bengal State. The Secondary data are collected from the official websites of various departments of the Central Government and the Government of West Bengal such as Animal Husbandry & Dairying (DAHD), Department of Fisheries, Central Statistical Organization(CSO), FISHSTAT PLUS and FAOSTAT database maintained by FAO, FIGIS; an official website maintained by FAO for statistical queries on fisheries database, etc.

1.11 Methodology of the Study

The analytical part of the study consisted of the measurement of the resource use efficiency of pond fishery at the individual farm level and identifying the sources of inefficiencies for

them. The study intends to estimate two measures of efficiency at the farm level− technical and scale efficiency.

The resource use efficiency measurement method is broadly divided into the parametric and non-parametric approaches. The two methods differ from each other due to the assumption of a particular functional form of the production function in the parametric approach and the absence of the same in the non-parametric approach. The parametric approach has been traditionally assimilated into the stochastic frontier production function approach (SFP) whereas the non-parametric approach has been customarily incorporated into Data Envelopment Analysis (DEA). The present study uses both DEA and SFP to evaluate the technical efficiency and scale efficiency of pond fish farming units in North Bengal on the basis of observed data.

While the main disadvantage of the parametric method is the difficulty involved in selecting a specific functional form and making the distributional assumption about the data, it has the advantage that statistical inference can be made from the obtained results. The advantage of DEA is its flexibility in terms of imposing less restrictive assumptions for the representation of the production technology. DEA does not impose any assumption about functional form. Hence, it is less prone to misspecification errors. It does not take into account the random error. It is not subject to the underlying distribution of the error term. So, it does not take into account such statistical noise, but the efficiency measures will be biased if the production process is largely characterised by stochastic elements. However, a major drawback of the DEA method is that it does not make any distinction between technical efficiency and statistical noise effects, with the result that any deviation from the frontier is attributed to inefficiency.

The stochastic frontier production function approach (SFP) can considerably supplement the DEA study by helping us to identify, through the application of standard hypothesis tests, the resource inputs to which efficiency gain can be attributed. Thus, the use of a stochastic approach makes it possible to take care of noise in the data set that might result when respondents provide inaccurate or inconsistent information on farm operations.

In the exploratory part of the study, several statistical tools are used to analyse and understand the secondary data. These include descriptive statistics, histograms and bar charts, compound annual growth rate (CAGR), etc.

1.12 Research Gap

In the context of North Bengal, research on the technical efficiency of pond fishery is scanty. Thus, there is an emerging need for conducting a sample study in order to investigate the resource utilisation pattern of pond fishery in North Bengal. This can help understand the economic rationality behind the emerging smallholder pond fish farming sector as well as the impacts of such changes in the rural economy on the regional economy of North Bengal. It is also to be mentioned that the examination of efficiency is a central issue in judging the performance of a production unit such as a pond fish farm. The studies of efficiency/inefficiency also help us to identify the factors causing inefficiency as well as their quantification. But all most no such empirical research has been carried out yet. The proposed study aims to bridge this research gap.

1.13 Chapterisation Scheme

The entire research study has been organized systematically in the form of eight chapters coupled with a bibliography and appendices for better understanding and fair presentation. A brief outline of the chapterisation of the study is presented as under:

The **first chapter** entitled –Introduction" presents an overview of the entire research study. It also explains the rationale and importance of the study and sets out the objectives, research questions, and research hypotheses. Moreover, this chapter delineates the techniques of data collection and the methodology of the study. Lastly, it tries to point out the research gap.

The **second chapter** entitled –A Brief Overview of the Fishery Sector in India vis-á-vis West Bengal" gives an overview of the growth and development timeline of the fishery sector in India and West Bengal, respectively. This chapter suggests effective measures for the development of inland fishery in India and West Bengal.

Chapter three attempts to know the fishery development scenario of the region of North Bengal vis-à-vis the identification of major challenges and opportunities related to inland fishing activities in the region.

Chapter Four discusses the fish marketing system in North Bengal. This study is conducted in order to assess the marketing efficiencies in terms of gross marketing margin (GMM) and percentage share of fishermen in the consumer rupee (PSFCR) among other indicators.

Chapter Five presents an overview of the approaches to the measurement of efficiency. It makes an effort to define the frontier concept put out by Farrell and its computational application through the development of a number of efficiency measuring techniques. These techniques essentially show the way of practical identification of an efficient frontier from a given set of observations on inputs and outputs. Once a benchmark frontier is constructed, the efficiency can be measured by the distance of any production unit from that frontier. The various approaches for estimating efficiency can generally be categorised under two distinctly opposite groups of methods: non-parametric and parametric methods. Data Envelopment Analysis (DEA) is an approach of the first type while Stochastic Production Frontier Analysis (SPF), or alternatively, stochastic frontier analysis (SFA), belongs to the second category.

Chapter Six performs stochastic production frontier analysis for the measurement of the technical efficiency of fish farming ponds in the study regions. Using the results of stochastic frontier regression, it tries to evaluate the relative effects of various productivity parameters on pond fisheries so that the relative significance of each parameter could have been better understood.

Chapter Seven makes an effort to apply the data envelopment analysis (DEA) approach to measure the technical efficiency (TE) of pond fisheries. Additionally, it aims to demonstrate whether there is room for performance improvement through proper resource allocation and utilisation. The analyses of scale efficiency and returns to scale (RTS) have also been made in this chapter.

Finally, **Chapter Eight** presents a summary of the empirical finding of the study. Additionally, it identifies certain thrust areas where the current study may be expanded with ease.