1.0 Introduction

The environment, in the form of natural resources, provides energy and materials that are used to produce goods and services to satisfy human needs. Traditional usage confines the term natural resources to naturally occurring resources and environmental and ecological systems that are useful to mankind or can be useful under feasible technological, economic, and social circumstances. Examples of natural resources are forest, land and its multiple products and services (e.g. coal, aluminum etc.), natural land areas preserved for aesthetic, recreational, or scientific purposes; the fresh and salt water fisheries; mineral resources that include mineral fuels and non-fuels (e.g. coal, aluminum etc.); non-mineral energy sources of solar, tidal, wind and geothermal systems; water resources and also the waste assimilative capacity of the environment and ecological systems.\(^1,2\)

1.1 Renewable and Nonrenewable Resources

The natural occurrence of resources in the earth’s crust represents resource endowment.

Natural resources may be either renewable or nonrenewable, depending on their rates of regeneration in nature. Renewable resources are those that are replaced in nature at a rate close to their rate of use. Nonrenewable resources exist in fixed...
amounts or are used up faster than they can be replaced in nature. Stocks of renewable resources like fish grow through regeneration; while exhaustible resources like coal are available in fixed quantities. A nonrenewable resource cannot be re-made, re-grown or regenerated on a scale comparative to its consumption. Therefore, these resources are also called exhaustible resources. Fossil fuels such as coal, petroleum and natural gas are common examples of nonrenewable resources. These resources are exhaustible because their formulation requires millions of years. It is not an economically meaningful time frame. A renewable resource differs in that it may be used, but not used up.

Renewable natural resources are capable of self-reproduction. For some renewable resources, such as solar energy, the amount consumed by one generation does not alter the amount available for subsequent generations. Solar radiation, tides, winds and hydroelectricity are perpetual resources that are in no danger of being used in excess of their long-term availability. For some renewable resources, the time taken to grow to maturity represents their rate of regeneration in nature. The continuation and volume of their flow depends on humans. For instance, over-harvesting reduces the stocks of fish, which in turn reduces the rate of natural regeneration of the fish population. Biomass such as forests, animals, aquatic flora and fauna are some other renewable resources that must be carefully managed to avoid exceeding the environment's capacity to replenish them. Over exploitation may even lead to extinction of the otherwise renewable resource. The challenge for managing renewable resources involves the maintenance of an efficient, sustainable flow. During a particular time period the stock of a resource depletes at the rate of harvesting or extraction per period. These attributes of natural resources have much in common with man-made capital. Just as investment increases and depreciation
reduces the stock of man-made capital, so growth through regeneration increases and harvesting or extraction depletes the stock of natural resources.  

1.1.1 Fisheries as natural renewable resource – scope and significance

A life cycle assessment of biological renewable resources such as fisheries provides a systematic means of evaluating their renewability. Fisheries are living ecosystems- natural or controlled, yielding food benefits for which the effort in the form of capital and labour can be studied from an economic as well as an environmental angle. Fish plays an important role in the diet and health of the population giving high quality and easily available protein for all age groups. Fisheries offer significant livelihood to many people engaged in this activity, thus contributing to food security and poverty alleviation. Besides being the source of livelihood to economically weaker sections of the population, fisheries stimulate growth of a number of subsidiary industries and earn foreign exchange.

Fisheries can be practiced at any scale-large or small. It can be carried out in marine waters or inland waters, through capture as well as culture.

1.1.2 Fish as food

Fish is one of the most versatile food commodities and can be utilized in a great variety of ways and product forms. It is generally consumed either live, fresh, chilled, frozen, heat-treated, fermented, dried, smoked, salted, pickled, boiled, fried, freeze-dried, minced, powdered or canned, or as a combination of two or more of these forms. However, fish can also be preserved by many other methods. The trade in live fish is special.
1.1.3 Fish and nutrition

Fish contributes to food security in many regions of the world, providing a valuable supplement for diversified and nutritious diets. Fish is highly nutritious. It provides not only high-value protein, but also represents an important source of a wide range of essential micronutrients, minerals and fatty acids. On average, fish provides about 20–30 kilocalories per person per day. It provides higher levels, up to 180 kilocalories per person per day, only in a few countries where there is a lack of alternative foods, and where a preference for fish has been developed and maintained (for example in Iceland, Japan and some small island developing states). The dietary contribution of fish is more significant in terms of animal proteins, which are a crucial component in some densely populated countries where total protein intake levels may be low. In fact, many populations, those in developing countries more than those in developed ones, depend on fish as part of their daily diets. For them, fish and fishery products often represent an affordable source of animal protein that may not only be cheaper than other animal protein sources, but preferred and part of local and traditional recipes. While the average per capita fish consumption may be low, even in small quantities fish can have a significant positive nutritional impact by providing essential amino acids that are often present only in low quantities in vegetable-based diets.  

1.1.4 Aquaculture and Culture-based Fisheries

There has been a spectacular growth of global aquaculture with an annual growth rate of about 10%; production has doubled in each of the last two decades. Aquaculture has been the world’s fastest-growing food production sector for nearly two decades.  

Given the significant growth in production and value, and expansion of aquaculture and aquaculture-related activities, it is generally believed that aquaculture and culture-based fisheries hold much promise for meeting increasing food demands. In fact, aquaculture is overwhelmingly concentrated in the developing world, especially in Asian countries, providing important nutritional and economic benefits to rural communities, and, with few, if any, adverse environmental effects being experienced with low-input systems that make up the bulk of aquaculture production. Exports of high-value species earn much needed foreign currency in many developing countries. More importantly for food security, the production, processing and sale of fish offer the prospects of improved nutrition in rural and urban areas by providing a ready source of affordable high-quality protein as well as giving an opportunity to generate income, while diversifying production and reducing risks of relying on production of one or few types of products only. Aquaculture can be practiced both in coastal as well as inland areas.

1.1.5 Importance of inland fisheries

Landings from inland waters remain essential and irreplaceable elements in the diets of both rural and urban people in many parts of the world, especially in developing countries. Inland fish production provides significant contributions to animal protein supplies in many rural areas. In some regions freshwater fish represent an essential, often irreplaceable source of high quality and cheap animal protein crucial to the balance of diets in marginally food secure communities. Most inland fish produce is consumed locally, marketed domestically and often contributes to the subsistence and livelihood of poor people. Increasingly, some inland fish products are also traded internationally generating foreign exchange. The degree of participation, including a significant number of women and children, in fishing and fish farming can
be high in some rural communities, and fish production is often undertaken in addition to agriculture or other activities. Inland fisheries often provide a means of subsistence to the marginal and poor communities either as an annual activity or at least for a few months in the year, as either the sole or supplementary provider of income.

1.1.6 Types of inland fisheries

Inland fisheries can be practiced in following:

1. Flowing waters of rivers, lakes and streams.
2. Impounded waters of lakes, reservoirs, tanks, dams.
3. Naturally occurring or man-made ponds.

Within inland waters, fundamental differences exist between fisheries in ponds, tanks and reservoirs compared to those in rivers. The pond and tank fisheries tend to be of smaller scale, to be based on a relatively small number of target species and to be located in relatively more protected systems. Rivers are highly influenced by year-to-year variations in rainfall, the fisheries are based on large numbers of species and the systems are open. Reservoirs cover a range of possibilities intermediate between rivers and ponds.

1.1.7 Small scale inland fisheries – nature and importance

About 90 per cent of fishers worldwide are small-scale fishers, some 50 percent of fish used for direct human consumption is harvested by this sub-sector, and it provides livelihoods to millions of people in poor fishing communities. Small – scale fisheries can be broadly characterized as a dynamic and evolving sector employing labour intensive harvesting, processing and distribution technologies to exploit marine and inland water fishery resources. The activities of this sub-sector,
conducted fulltime or part-time, or just seasonally, are often targeted on supplying fish and fishery products to local and domestic markets, and for subsistence consumption. Export-oriented production, however, has increased in many small-scale fisheries during the last one to two decades because of greater market integration and globalization. While typically men are engaged in fishing and women in fish processing and marketing, women are also known to engage in near-shore harvesting activities and men are known to engage in fish marketing and distribution. Other ancillary activities such as net making, boat-building, engine repair and maintenance, packaging and processing etc. can provide additional fishery-related employment and income opportunities in marine and inland fishing communities. Small-scale fisheries operate at widely differing organizational levels ranging from self-employed single operators through informal micro-enterprises to formal sector businesses. This sub-sector, therefore, is not homogenous within and across countries and regions and attention to this fact is warranted when formulating strategies and policies for enhancing its contribution to food security and poverty alleviation.  

Although aquaculture is possible across varying scales of costs, inputs, place of culture and size of the fish-farm, small-scale fish-culture or pond culture is considered to have the greatest potential and has been shown to have correspondingly greater impact on poverty alleviation.

1.1.8 Fisheries, food security and poverty alleviation

The 1996 World Food Summit defined food security as “a condition when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life”. A country’s capacity to produce sufficient food to feed its population, referred to as national food self-sufficiency, is neither necessary nor sufficient to
guarantee food security at the individual/household level. Some countries may be food self-sufficient, yet remain with a large proportion of their populations suffering conditions of food insecurity; other countries may not be self-sufficient yet exhibit little food insecurity due to a strong capacity to import. Food security, therefore, is brought about by a combination of individual, household, community, national and even international factors. In particular, for national self-sufficiency to ensure individual food security, it requires and presupposes efficient “trickledown” and redistribution mechanisms, and transfer-based entitlements (i.e. individual-based access to these mechanisms). 6

Another aspect of food security is its linkage to the production process. Fishing can contribute directly to food security through the supply of fish itself (i.e. through subsistence mechanisms). But it may also contribute indirectly to food security through revenues generated from production and related processing and marketing activities (whether individuals are self-employed or on wages) which can then be used to purchase food.

Edwards (1999)7 has analyzed how rural aquaculture can contribute to poverty alleviation as, “rural aquaculture contributes to the alleviation of poverty directly through small-scale farming of aquatic organisms for domestic consumption and/or income; or indirectly through employment of the poor as service providers to aquaculture or as workers on aquatic farms of wealthier farmers; or indirectly by providing low-cost fish for poor rural and urban consumers.”

Food security is a fundamental dimension of poverty. People who are chronically poor usually lack access to adequate food. Malnutrition negatively affects people's working and learning capacity, and may affect vulnerable groups living just...
above the poverty threshold, causing them to enter the ranks of the poor. Eliminating hunger and malnutrition, therefore, is a precondition for the eradication of poverty.

Thus, fisheries can play an important role in addressing the problems of hunger and poverty.

1.1.9 Potential for inland fisheries in India

The inland fisheries resources of India include a length of 0.2 million kilometers rivers and canals, 2.4 million ha of ponds and tanks, 1.07 million ha of beels, jheels and derelict waters plus in addition 0.12 million km of canals, 3.15 million ha of reservoirs and 0.8 million ha of upland lakes. Two decades back most of the inland fish production was obtained from the capture fishing methods, concentrated along rivers, reservoirs and lakes. Traditional fishing communities engaged in capture fishery. But, the fish production from natural waters like rivers, lakes, canals, etc. has been observed to be following a declining trend, primarily due to indiscriminate fishing, habitat degradation and proliferation of man-made water control structures. Over the years, there has been a shift in focus from capture fisheries in open water bodies like rivers and lakes to intensive freshwater aquaculture in reservoirs, ponds and tanks spread across the rural landscape of the country.\(^8\)

Harnessing the river waters for irrigation as well as for hydro-electricity has been the main focus of developmental activities in India in the first five decades after independence. In the rural landscape, lot of stress has been laid on providing irrigation facilities through storing waters of perennial or seasonal rivers to provide water for the primarily rural and agro-based village economy. Consequently, there has been a creation of large number of man-made lakes, reservoirs and water-storage tanks dotting the country’s landscape. These man-made water-bodies hold tremendous
potential for inland fisheries development in India has long been recognized. However, this vital resource is not contributing to the inland fish production of the country to the extent it should. Unlike the rivers, which are under the increasing threat of environmental degradation, the reservoirs, ponds and tanks offer ample scope for fish yield optimization through adoption of suitable management norms. Any attempt to increase fisheries productivity in the country has to rely heavily on these water bodies. The sheer magnitude of small inland water bodies in the country, the closed system nature of this resource, makes it possible to secure a substantial increase in fish production by simple enhancements and by aquaculture.9

India utilizes only about 40 per cent of the available freshwater systems of lakes, ponds, tanks and reservoirs for inland fishery, as per various field studies. Thus, lot of further scope exists to improve this resource utilization.

1.2 Choice of Subject

1. As the primary objective of fisheries- be it capture or culture, is to ensure food security and economic betterment of the poorer sections of the society in particular, study of the subject with these objectives in mind is essential. If fish culture in land-locked areas is to be developed as a provider of improved food-security for rural households and aid in poverty alleviation.

The freshwater aquaculture sector is poised for a quantum jump in the next few decades, if the FAO Fish 202010 projections are to be believed. This has implications for improving the productivity of the village aquatic resources and further improving the livelihood opportunities and food security of the poor. With the change in the property regimes from open access to common property resource to
partially private ownership and intensification of fishery practices, it is pertinent to study the institutional changes occurring in the sector. It is essential to know the people being left out and the people benefiting as a change in property regimes occur in the sector. This will throw light on the policies necessary to make the process of growth more equitable and sustainable in the long run.

Within the inland freshwater resource sector, reservoirs, ponds and tanks provide readily available area of water resource that can be utilized for fisheries and aquaculture. These water bodies can have natural fish fauna, besides other living forms. They can also be stocked or enhanced through simple practices for increasing their productivity and thus serve as sites for profitable aquaculture. It has been estimated in some studies\(^{11}\) that the average Indian production from still-water village ponds and tanks has increased from 600 kg/ha/year in 1970s to over 2200 kg/ha/year by 1999-2000. There is further potential for it to increase to 5000 kg/ha/year in the coming years. Only 20 per cent of the overall potential has been utilized in freshwater aquaculture as per various studies, thus having potential for both vertical and horizontal expansion in the future.

A total of 40-lakh hectare area in the country is under fresh water tanks, reservoirs and ponds. Focus of utilization of the vast potential of pond and tank fishery resource in India as a part of policy framework can be a big step in addressing the problem of poverty and hunger in a sustainable manner and could contribute to the fulfillment of the United Nation’s Millenium Developmental Goals.\(^{12}\)

From this point of view, it is necessary to assess the economic and environmental aspects of renewable resources in general and fisheries in particular. A lot of work has been done in case of marine fisheries at global and national levels by researchers and scholars. However, very few studies are available on economic and
environmental aspects of inland reservoir, pond and tank fisheries. The present study is thus undertaken keeping the afore-mentioned objectives in mind.

Ponds and tanks can be both government or privately owned. Productivity levels of inland tanks, ponds and reservoirs often depend on initiatives in investment and economic efficiency factors. Physical-environmental characteristics, the socio-economic environment, institutional arrangements for managing fish production and associated activities are the most important factors in determining the productivity of these water bodies. Therefore, this resource system needs a closer observation and detailed investigation. Hence, small-scale fisheries of ponds and tanks pertaining to Aurangabad district (M.S.) have been selected as the focus of study for the present research work.

1.3 Objective

The main objective of this research work is to assess the economic and environmental aspects of fisheries in general and inland tank and pond fisheries in particular with respect to Aurangabad district of Maharashtra. However, following are the specific objectives of this study:

1) To study the inter-linkages between economics, environment and fisheries.

2) To study the environmental aspects of inland tank and reservoir fisheries.

3) To study the economic aspects of inland tank and reservoir fisheries.

4) To study socio-economic and cultural aspects of fish farm communities.

5) To study the prevalent practices for utilization of inland tank and reservoir fisheries.
6) To suggest economically feasible and environmentally sustainable inland reservoir/pond/tank fishery model.

1.4 Hypothesis

Hypothesis is usually considered as the principal instrument in research.

In this study following hypotheses are made in view of objectives in mind and are supported on the basis of data collected from sampled ponds and fishermen families of the ponds and reservoirs in the study area:

1) An inland reservoir fishery can contribute to food security.

2) An inland reservoir fishery generates employment and income potential.

3) An inland reservoir fishery has a definite economic impact in the geographical area of its location.

4) Environmental characteristics determine the location of an inland reservoir fishery.

5) Optimum utilization of fishery potential of inland tanks and reservoirs can be instrumental in eradication of poverty and hunger.

1.5 Methodology

The adoption of sound methodology in any economic investigation forms a vital part of the research study. It consists of study area, sampling technique, designing of schedule(s) or questionnaire(s), collection of data, analysis of data, and
finally, presentation and interpretation of the data. The following different aspects of methodology are adopted in this study.

1.5.1 Scope of the study

In order to study economic and environmental aspects of renewable resources, a case of fisheries is considered. Further, for detailed investigation the scope of this study is restricted to inland ponds, tank and reservoir fisheries only.

Culture fishery or aquaculture development involves many disciplines such as agriculture, economics, engineering, food-processing, genetics, irrigation, legislation, marketing, pathology, planning, sociology, remote-sensing, soil-science and taxonomy. Therefore, it has been necessary to limit the study to aspects practically observed and to the subject area where inter-linkages between economics, environment and resource use can be detailed.

1.5.2 The area under study

Aurangabad district is selected for the purpose of assessing economic and environmental aspects of inland reservoir fisheries. Reservoir, tank and pond fisheries in Aurangabad district are studied.

Profile of Aurangabad district

Aurangabad district is located in the state of Maharashtra in India. Aurangabad is a land-locked district located between 19-20 degrees north latitudes and 74-76 degrees east longitudes in the centre of the state of Maharashtra. It is the headquarter of the Marathwada division, one of the six political and administrative divisions into which the state is divided. It spans across an area of 10,100 kilometers square, out of which 98.6 % area is classified as rural. There are 9 talukas or smaller divisions in
Aurangabad district, namely- Aurangabad, Paithan, Fulambri, Vaijapur, Khultabad, Gangapur, Sillod, Soygaon and Kannad. These comprise a total of 1344 villages.

The total population of Aurangabad district (as per Government of India Census 2001) is 28.97 lakhs, out of which about 70% resides in the rural areas. The primary occupation is agriculture, with jowar, corn, bajra, cotton and sugarcane being the major crops.

**Potential for fisheries in the local area**

Besides the flowing rivers and streams, there are a total of 1867 water tanks, ponds and reservoirs of various sizes, occupying a total of 16,632.5 ha area new. These are mostly rain-fed and are used for practicing fisheries. There are almost 2000 privately owned small farm-ponds that can vary in size from 10 sq. meters to about half an acre. Some of these are also used for practicing fish culture. The district has the biggest state government-funded fish-seed hatchery located at Paithan. Thus, excellent potential exists for practicing fisheries and aquaculture in the local water bodies.

1.5.3 **Approach for studying economic and environmental aspects of inland reservoir fisheries**

In the present study, in order to assess the economic and environmental aspects of inland reservoir fisheries, the pattern and practice of fishery is studied in the selected reservoirs, tanks and ponds of varying sizes in Aurangabad district. The studies are detailed, compared and contrasted across various parameters such as size of water body used for the fishery, type of practice of fishing, organization and management of the fishery, inputs used, productivity, socio-economic and cultural aspects of fishermen and fish-farm owners etc.
1.5.4 Nature and Method of data collection

We have used both primary as well as secondary data in this study.

1) Secondary data

Secondary data for the global scenario has been compiled from various publications of the Food and Agriculture Organisation (FAO), World Bank, World Fish Centre and the United Nations (UN) available online as well in the library. Online reports available from the World Resources Institute (WRI) have also been used. For secondary data pertaining to India, publications and reports of the Fisheries Department of the Central Government have been relied upon. Secondary data from Central Institute of Fisheries Education (CIFE), Central Inland Fisheries Research Institute (CIFRI), Indian Agriculture Research Institute (IARI) has also been made use of. Secondary data pertaining to the state level has been sourced from the annual reports of the state fisheries department of the Government of Maharashtra. This secondary data is used for studying the economic and environmental aspects of fisheries at the macro level. Secondary data on the local fishery resource of the Aurangabad district is collected from the office of the district fisheries development officer. Besides, the annual report of Aurangabad district and information available with the departments of irrigation and agriculture were also used for additional secondary data.

2) Primary data and design of questionnaire (schedule)

Primary data are collected for assessing economic and environmental impact of inland pond and tank fisheries at the micro-level by way of household survey and field visits. A special questionnaire was developed for collecting household data from sampled fishermen who practice fishing and aquaculture within the inland tanks and
ponds. Care was taken to construct simple questions, and units enumerated wherever necessary. An appropriate and logical sequence was followed.

A pilot survey was conducted before the main survey in order to pre-test the questionnaire. Accordingly minor modifications were made in the questionnaire for the sample survey to capture the field data on the economic, environmental and socio-economic aspects of pond and tank fisheries and the fish farm communities in Aurangabad district, to the maximum detail possible.

1.5.5 Sampling design

Multistage stratified random sampling technique is adopted for organizing sample survey in the present study.

Aurangabad district is found to have a total of 1867 water tanks, ponds and reservoirs as per data available with the Department of fisheries, for this purpose. A majority of these water bodies are man made, i.e., for the main purpose of irrigation. Some serve as percolation tanks and a miniscule number are naturally occurring ponds and lakes. These inland water bodies of varying sizes constitute the population size, i.e. available area for the development of inland fisheries and aquaculture. Thus, the sample has to be selected from amongst these water bodies.

About 10 per cent of the total ponds and tanks were randomly selected as sample size for studying the economic and environmental aspects of inland reservoir fisheries in Aurangabad district. Care was taken to select reservoirs and ponds of all sizes, i.e., large, medium and small. Further, it was also ensured that some ponds and tanks from each of the 9 geographical regions or talukas of the district are included in the sample. Since the talukas vary in size and according to the density of ponds and tanks constructed in them, we tried to include around 10 per cent of the available
ponds and tanks in the initial sample. On a pilot survey, it was noticed that certain ponds and tanks included in the initial sample were running dry, or were not functional. In some cases, the water body in question was found embroiled in some legal case, due to which data collection appeared unreliable at best. Significantly less number of ponds and tanks could be sampled in talukas of Gangapur and Vaijapur. This was so because of less number of water bodies in these areas to begin with. Moreover, a majority of the selected ponds and tanks were found to be running dry or not being used for fishery in these areas. Finally, a total of functional 119 ponds and tanks were sampled for the research work. It has also been attempted to give a fair representation to both rural as well as urban areas in the sample. Out of the total number of ponds and tanks (1867), only about 350 (less than 20%) were found to be suitable for fishery during the study period. The proportion of ultimate sample size to these functional ponds and tanks then comes out to be about 34 percent, which is more than the designed sample size. The sample size selection is given in Table 1.1.

Table – 1.1 Selection of Sample Size:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Taluka</th>
<th>Total no. of ponds and tanks</th>
<th>No. of ponds and tanks in initial sample</th>
<th>No. of ponds and tanks in final survey sample</th>
<th>No. of sampled fish farmers/fishing households</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kannad</td>
<td>234</td>
<td>23</td>
<td>17</td>
<td>62</td>
</tr>
<tr>
<td>2</td>
<td>Soygaon</td>
<td>282</td>
<td>28</td>
<td>18</td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>Sillod</td>
<td>275</td>
<td>27</td>
<td>16</td>
<td>43</td>
</tr>
<tr>
<td>4</td>
<td>Phulambri</td>
<td>161</td>
<td>16</td>
<td>15</td>
<td>99</td>
</tr>
<tr>
<td>5</td>
<td>Aurangabad</td>
<td>310</td>
<td>31</td>
<td>24</td>
<td>75</td>
</tr>
<tr>
<td>6</td>
<td>Khultabad</td>
<td>180</td>
<td>18</td>
<td>11</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>Vaijapur</td>
<td>115</td>
<td>11</td>
<td>3</td>
<td>18</td>
</tr>
</tbody>
</table>
The actual fishermen who hold license to fish in these water bodies are then selected with random sampling and interviewed personally. We have tried to sample around one-third of members of fishermen from each fishery included in the sample. In case there is a variation observed amongst the members of a co-operative society managed fishery in terms of their division of labour within the co-operative society, care has been taken to include members of each type into the sample, i.e., those who actually catch fish or the fishermen versus those who play some other role within the society.

Secondly, individual farmers are observed to dig small farm ponds in their farm land. These are mostly of a size of 0.3 X 0.3 R. In some of these cases, the farm ponds may have a small-scale fishery also. The number of total farm ponds at the time of study was found to be around 2000 in number. However, during a field tour and a random sampling, only about 2 % (38) of these farm ponds were found to be stocked. 10 of such individual fish-farmers were also interviewed by the schedule method. Table 1.2 gives the total sampled fishermen for the purpose of this study.
Table 1.2 Total Sampled Fish Farmers

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Fishery type</th>
<th>No. of sampled fishermen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fishery co-operative</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Holding fishing right</td>
<td>504</td>
</tr>
<tr>
<td></td>
<td>b) Not holding fishing right</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>Individual farm pond</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Doing fishing</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>b) Not doing fishing</td>
<td>?</td>
</tr>
<tr>
<td>3</td>
<td>Adjoining area no.</td>
<td>?</td>
</tr>
<tr>
<td>4</td>
<td>Fishing</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>514</strong></td>
</tr>
</tbody>
</table>

Earlier members of co-operative societies who are no longer holding fishing rights in public water body have also been interviewed for comparison. Also, a number of families are selected from areas around those tanks and reservoirs in which there is no fishing activity. In the case of individual farmers, farmers having farm ponds but not doing aquaculture were also interviewed. These constitute the ‘control group.’

### 1.5.6 Field survey for collecting primary data

The questionnaire was canvassed among sampled fishermen by way of direct personal interview method. A schedule of interviewing was prepared and the potential interviewees were contacted whenever possible, to seek their time for conducting the interviews. Care was taken to conduct interviews at the site of fish-pond or at a community centre in the villages where various interviewees could come together and provide maximum information. However, care was taken not to disturb any of the fishermen during their busy hours. Help was also sought from local village
functionaries like the talathi, gram sevak etc to ensure accuracy of data related to technical aspects such as size of government owned ponds etc. At times, field officials from the department of fisheries were accompanied on their visits to various ponds, so that technical factors and the procedure of fishery operation could be better understood. This also helped in understanding the role of government in development and promotion of fishery. Visits were made to local fish markets to observe the procedure of marketing and sales. A visit was also paid to the government hatchery to study the procedure of cultivation of fish seed and its sales to fish farmers. Care was taken to visit fishery sites at times of various operations, such as during pond preparations prior to stocking, the time of actual stocking, rearing period, feed and fertilization time, harvest time etc. While it was not possible to visit each and every pond or tank surveyed for all the operations or procedures, the visits were staggered over the duration of almost a year so that all the procedures could be studied in the field at least somewhere or the other. In some cases, additional data provided by the interviewees such as some family problem etc, that was not a part of the canvassed questionnaire, was also made a note of, so that the socio-economic and cultural issues could be studied in a holistic manner, without any formal constraints.

1.5.7 Time period of sample survey

The year 2007-08 was a normal year, in the sense, that there was an adequate rainfall received in the inland reservoir areas under study. The availability of water was also adequate in the area of inland fisheries studied. In contrast, the year 2008-09 was a ‘drought-akin’ year, for the rainfall was not only delayed but also inadequate in the inland reservoir areas. Hence, the economic and environmental aspects of inland pond and tank fisheries have been studied for both the years 2007-08 and 2008-09. The data collected and observations made have been compared and contrasted to
reach conclusions for studying economic and environmental aspects of small-scale inland pond and tank fisheries.

1.5.8 Techniques and tools for analysis and presentation of data

In the present study, we have used both time-series data as well as cross-sectional data. For trend analysis of fishery production and economics of inland pond and tank fisheries, time series data has been used and for comparison of fishermen and fish farm communities, cross-section data has been used.

The data, after collection, has to be processed and analyzed for drawing inferences and making suggestions on the basis of it. In present study, simple statistical tools, viz. averages, frequencies, percentages etc are used for comparison of data. Range, standard deviation and coefficient of variation are used to study the variability of data. Advanced statistical tools like co-relation and regression analysis are used for analyzing degree and type of relationship existing between different variables and predictions and forecasting respectively. Testing of hypotheses etc, are used for analysis and comparison of data. The collected data are processed and presented in the form of tables, graphs, figures, diagrams, bars, pie-charts and maps for analysis and interpretation purposes. The benefit-cost ratio analysis, the environmental impact and sensitivity analysis are the methods used for studying economic and environmental viability of inland reservoir fisheries in Aurangabad district.

1.6 Limitations of the Study

Following are a few limitations of the present study.

1. Non-availability of sufficient secondary data pertaining to local level or the study area seriously limits the scope of this study.
2. A complete list of inland water resource of Aurangabad district is required for assessment of the fisheries potential of the Aurangabad district. Since different aspects of these inland water resources fall under the purview of different government departments such as Irrigation department of the state, the local sector irrigation department, the ZP sector irrigation department, the agriculture department as well as fisheries department and each department is found to have a different set of data for classification and enumeration for the inland water body resource of the district, data provided by the fishery department is assumed to be reliable for the purpose of this research work.

3. The data was collected from the sampled fishermen/ fishing families for the years 2007-8 and 2008-9 and the data given by fisher folks is assumed to be reliable. Efforts have been taken to canvass the sample survey questionnaire in the vernacular, in order to reduce the recording and information errors.

4. The present study is a sample study. Therefore, cent percent accuracy cannot be expected. However, care has been taken to reduce sampling error by way of selecting a representative sample.

5. The economic and environmental aspects of inland fisheries can also be studied across other districts of Maharashtra. However, due to vast geographical distances, resource constraints and largely seasonal nature of the aquaculture activity, the inland reservoir fisheries in Aurangabad district have been concentrated upon in greater detail, with actual primary data collection and household survey being done in Aurangabad district only.
1.7 Chapter Scheme

The study is divided into the following eight chapters. The chapter scheme has been designed keeping in view the objectives of the present study.

Chapter I: Introduction, Objectives and Methodology

After introducing the subject and presenting an overview of fisheries as a renewable resource, specific objectives of the study along with methodology adopted have been discussed in chapter I. Importance of inland reservoir, pond and tank fisheries in development process and development of fisheries potential in India and Maharashtra along with Aurangabad region has also been discussed in this chapter. Food security and Poverty alleviation have been accorded a special mention in this regard.

Chapter II: Review of literature

Chapter II deals with review of literature. A number of scholars and researchers as well as international organizations like the United Nations (UN), World Bank, Food and Agriculture Organisation (FAO) and national level institutions like the Central Inland fisheries Research Institute (CIFRI), Central Institute of fisheries Education (CIFE) etc have worked on various aspects of fisheries. In their publications, works and documents from time to time, various economic as well as environmental aspects of inland fisheries with respect to the question of food security and poverty alleviation have been dealt with by the Food and Agriculture Organisation of the United Nations (FAO). The latter has published various technical papers, guidelines and corporate documents for sustainable and beneficial utilization of fisheries potential in the world. Many scholars have studied the fishery potential in India out of which some works lay special emphasis on inland reservoir as well as
pond and tank fisheries. Institutions like National Academy of Agriculture Research Management (NAARM) etc in India have brought out studies evaluating fisheries practices in the country and these have been reviewed according to their applicability in the present study.

Chapter III: Inter-linkages between economics, environment and natural resources

Chapter III studies the inter-linkages between economics, environment and natural resources. An objective assessment of the fish production potential of water-bodies has to take into account the diverse aspects of the resource utilization. The intimate relationship between economic activity and the ecosystem dynamics of the environment becomes particularly clear in the management of renewable resources in case of the fishery industry. Costs and benefits are directly impacted upon by the environmental variables, due to which fish catches and economics of subsequent activities are determined. Fisheries management has to build the population dynamics of cultured species into the economic model and to explicitly include the feedbacks, if their contribution to the nutritional, economic and social well-being of the growing world's population is to be sustained. Such inter-disciplinary aspects are explored in detail in this chapter, along with a description of these aspects as actually observed in the study area.

Chapter IV: Environmental aspects of fisheries

Productivity of aquatic water bodies depends, to a large extent, on the synergetic effects of a number of geochemical, meteorological, morphometric and hydrographic variables and the biotic communities present in the ecosystem. Environmental and physical conditions determine the choice of species most
importantly, influencing the biological factors of reproductive cycles, growth and maturity. These in turn influence the costs related to food, aeration, disease control, harvest, preservation and transport, thus directly having a bearing on the economics of fish farming. In chapter IV, the environmental aspects of fisheries are discussed and the area under study is described in detail with reference to the environmental conditions prevailing in Aurangabad district.

Chapter V: Economic aspects of fisheries

Improved understanding on economics of small-scale fisheries is important to provide a comprehensive understanding on socio-economics dynamics of fisheries to the households, local community, and national economy; to assess economic and financial sustainability of small-scale fisheries, and to analyze comparative advantage and sustainability of the sector; to evaluate importance of this sector to the rural livelihoods, in general; to analyze viability of community resources management institutions of this sector.

In chapter V, the economic aspects of fisheries are discussed with reference to observations made in the study. From preparation of tanks to introduction of fish seedlings or fry, to rearing, harvest and pest control, followed by marketing and distribution networks and the income generation- all these variables have been used to determine input-output, costs and benefits ratios. Economic viability has been given special emphasis in this chapter. Sensitivity Analysis has also been done to arrive at economically viable variables.
Chapter VI: Socio-economic and cultural aspects of fishermen and fish farm owners

A careful study of the socio-economic conditions of fishermen and fishing communities is a prerequisite for the good design and successful implementation of effective water and fishery resource utilization programmes. Such a study must provide an overall picture of the structure, activities, and standards of living of the fishing communities and households as a background to their occupation of fishing. It can also determine their relative positions in the national economy and establish whether government intervention to upgrade their position is needed.

Chapter VI describes the socio-economic profile and cultural aspects of fishermen and fish farm owners in such a framework. Direct observations made in the study and data collected in the household survey by way of field visits are described in this chapter. The main observations and conclusions drawn thereof are discussed subsequently.

Chapter VII: Inland Fishery Model

On the basis of this research work and the field studies conducted, three ideal models for sustainable and optimal resource use in inland pond and tank fisheries in Aurangabad district have been proposed in this chapter. These models can serve as a guideline to fish-farmers keen to take up aquaculture for utilizing the locally available inland water resource base and can serve as a ‘ready-reckoner.’ They can also be helpful in policy formulation.
Chapter VIII: Conclusions and suggestions

Based on the field survey, direct observations, primary and secondary data collected, conclusions reached about the economic and environmental aspects of inland pond, tank and reservoir fisheries in Aurangabad district are described in the chapter VIII. This last chapter sums up various facets of the research work and presents an overall picture of inland pond and tank fisheries in Aurangabad district. On the basis of these findings, suggestions are also given which are helpful for those who are engaged in the fisheries sector, research scholars in this area and policy makers.

Various appendices and tables that can be useful in interpreting this research work have been included towards the end, along with a copy of the schedule designed for primary data collection. Finally, a list of relevant readings, selected references and bibliography has been provided.
REFERENCES


12. www.un.org/milleniumgoals
