CHAPTER - 1

INTRODUCTION
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With remarkable achievements in the technology of aquaculture in the country the potentialities of its impact on the overall socio-economic status and quality of life of rural poor have increased considerably. Aquaculture not only relates to the production but underscores the necessity for judicious land utilisation, technology transfer and management of post harvest aspects for the reasons of extending the overall benefits to the population in general. For the purpose, the Government as well as other agencies in the country would need to evolve certain practical strategies.

Fish assumes in general a great importance in Asia mainly because 80-90% of World's total number of fishermen are in Asia, contributing to about 80% of aquaculture production and about 40% World's total fish production, both from capture and culture fisheries. For the last two decades, world wide attention is being focussed on culture fisheries. This is mainly due to the fact that most capture fisheries are operating at ecological potential levels and the potential and versatility of aquaculture are being increasingly realised.

Indian population would be around one billion by the turn of the century. On the other hand the land/water resource would
remain constant leaving an alternative for higher productivity per unit area. In this regard aquaculture has tremendous potential for raising the productivity per unit area. It could be an ideal component particularly when land is shrinking and per capita holding are becoming smaller.

Aquaculture resources in the country are - Tanks and Ponds 0.75 million ha, beels, ox-bow lakes and derelict water bodies about 1.0 million ha, brackish water and mangroves 0.9 million ha, reservoirs 1.45 million ha, rivers and canals 29,000 km., coastline 7517 km., and continental shelf 0.42 million square kilometers.

In the process of development it has been possible to cover more than 0.16 million ha. of water area under scientific aquaculture programme out of the available 1.5 million ha. of cultivable waters and 1 million ha of derelict, swampy, beels, mans, dead river courses and other such waters in the country. With the application of technology the prospects of advancements have been often depicted in relation to basic natural productivity of Indian water bodies in terms of their natural carrying capacity which generally should have been taken as a benchmark figure. The ad-hoc disposition of the planners in assessing the development without basic knowledge of the carrying of such tropical waters is an anomaly.

Ecology may be defined as the science of the inter-
relationship between living organisms and their environment (Allee, 1949) and it is this inter-relationship that is of prime importance in any consideration of the living resources. Biological production is the key to the extent to which such resources may be utilised for whatever purpose. There are factors affecting production both positively and negatively, and such factors are subtly different from those influencing production in the typically more comprehensively studied temperate regions. By an understanding of the factors that regulate production and determine the ecology of an aquatic system, one can aim at a planned and sensible utilization of regional resources.

Production and its efficiency and a thorough understanding of ecology are of paramount importance in the tropical aquatic system, where much of the supply of protein is feasible from fish culture in fish ponds.

The techniques of fresh water pond culture involve both management of soil and water and husbandry of fish. Management of soil and water is basically the same as in agriculture and fish husbandry as in livestock farming. However, unlike major agricultural crops, fish do not consume water and compared to any bird or mammal used for husbandry purpose, they have the highest fecundity. These two criteria go very much in favour of fish cultivation. Besides, fish provide high quality food rich in protein and vitamins, and contain fat, calcium, phosphorus and
other nutrients necessary for human health and growth.

Fish has 16-20% protein having essential minerals, vitamins, essential amino acids and unsaturated fatty acids and provides about 600-700 calories from a kilogram of its flesh. Fish also have a higher protein content than pork, e.g., 1 kg of medium fat pork is 8% protein and 41% fat compared to carp with 22% protein and 9% fat. Fish are even cheaper than vegetable protein in Taiwan, since the amount of protein in $1 worth of fish is 45% higher than meat, 58% higher than poultry, 47% higher than eggs, and 32% higher than vegetables. In the area of protein conversion fish ranks first. Protein conversion for beef/livestock is about 21:1, whereas for pork it is about 8:1; poultry 5.5:1; milk and egg 4:1 and for fish 3:1.

Fish usually have better food conversion efficiencies than livestock because they do not need as substantial a skeleton for support and movement as livestock, since they have more or less the same density as water. Thus, a higher proportion of their total weight is edible and less energy is required than for land animals for movement and support. Furthermore, since fish are cold-blooded animals, they do not use energy for the maintenance of a high and constant body temperature like warm-blooded birds and mammals (Edwards, 1980).

Fish are highest on the list in terms of gross live body weight gain 1000 g of feed intake; Steers 163, Pigs 292, Chickens
356, brown trout 576 and channel Catfish 715 (Hastings and Dickie, 1972). This was supported by a study from Taiwan which demonstrated that the rate of return on investment was higher for fish culture than for pig farming (Shang, 1973). The production cost of pigs was higher than that for aquaculture, mainly due to feeding costs since it costed about US $ 0.66 of feed to produce 1 kg of pig but only about $ 0.15 worth of feed and fertilizer to produce 1 kg of freshwater fish.

Ponds both natural and artificial ones are very much to use in rural areas of India. They are the natural source of drinking water as well as for all types of domestic work. The freshwater ponds and tanks scattered all over India, constitute the country's most valuable water resources for culture fisheries. The ponds serve as a very suitable and cheap waste disposal bins and have great potentialities for the development of inland fisheries.

Fish farming technology for ponds has been evolved after many years of dedicated and sustained research effort. Induced breeding of Indian major carps - *Catla catla*, *Labeo rohita* and *Cirrhina mrigala* and the exotic carps - *Hypophthalmichthys molitrix* and *Ctenopharyngodon idella* through pituitary hormone administration has been evolved at Cuttack in Orissa under the Central Inland Capture Fisheries Research Institute (CICFRI - formerly known as CIFRI). The exotic *H. molitrix* (Silver carp),
C. idella (Grass carp) and Cyprinus carpio (common carp) known for their excellent cultural value, were also bred at the Cuttak Centre of the Institute and later at different centres all over India under the All India Coordinated Research Project on Composite Fish Culture and Seed Production.

A high yielding carp polyculture production system based on the six ecologically compatible species (C. catla, L. rohita, C. mrigala, C. carpio, H. moliitrix and C. idella) was developed by Central Inland Capture Fisheries Research Institute (CICFRI - formerly known as CIFRI) in the 1960s. This technology of composite fish culture through adoptive research was extended in the 1970s through the All India Co-ordinated Research Project in a number of States in the country (Andra Pradesh, Assam, Bihar, Gujarat, Haryana, Maharashtra, Madhya Pradesh, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal), and a production of 2.5-10 tonnes/9 months to one year has been achieved. This carp culture system was also experimented in large-water bodies (1.5-2 hectare) at Krishna Nagar, Nadia (West Bengal) and a production of well over 4 tonnes/hectare/year was achieved (Sinha, 1988).

Early work during the 1950s and the early 1960s at the Pond Culture Station of CICFRI at Cuttack (Orissa) concentrated on improving the survival of naturally procured carp hatchlings in nurseries, which was around 10% to 15% only. Concerted research led to fertiliser/manure application schedules based on the nutrient and physico-chemical status of ponds, soil and water.
Treatments for controlling aquatic insects in nurseries and removal of unwanted weeds were developed. These led to development of nursery technology by the sixties and with further development with technology 80% survival has been achieved.

Another major achievement was the development of composite fish culture technology - a high yielding carp Polyculture which include the three Indian major carps and three exotic carps; Silver, Grass and Common carps. The carp breeding and culture technology development in a research farm of CICFRI in Orissa in the 1960s led to the establishment of All India Coordinated Research Project (AICRP) on composite Fish culture and Fish Seed Production, in 1971. Under the rural aquaculture project sponsored by the ICAR/IDRC in the States of Orissa and West Bengal, the viability of the technology in the farmers' ponds was also demonstrated.

A major National Programme of Fish Farmers' Development Agencies (FFDAs) at district level was initiated in 1973-74 to provide administrative and infrastructural support training of beneficiaries, mobilisation of inputs and extension support to fish farmers and arranging institutional finance through bank credits. Thus, while the FFDAs concentrated on utilising more of the fallow and unutilised ponds resources needing major development support, the traditional Fish Farmers of functional carp culture ponds upgraded the technology and improved the productivity of both seed and fish.
The FFDAs in the country were increased from 50 in 1979-80, which covered water area of about 1047 ha. Under fish culture, to 200 in 1988-89, covering about 2.45 lakh ha. water area (1989-90). The number of Fish Farmers trained in scientific fish farming under FFDA Programme till 1989-90 was about 2.96 lakhs. The average fish productivity has also gone up from 582 kg/ha/year in 1979-80 to 900 kg/ha/year by 1984-85 to 1330 kg/ha/year by 1987-88 to 1560 kg/ha/year by 1988-89 to 1865 kg/ha/year in 1989-90 in FFDA ponds. National Council of Applied Economic Research (NCAER, 1981) while evaluating the impact of FFDA on rural aquaculture found that in majority of the cases aquaculture is more profitable than even agriculture and animal husbandry. The number of FFDAs have gone up to 341 in the country during 1990 covering all the States and one Union Territory. The fry and fingerlings production went up from 1048 million in 1979-80 to 12,000 million 1989-90. The Inland Fish Production went up from 0.89 million tonnes in 1980-81 to 1.40 million tonnes in 1989-90, most of it coming from freshwater aquaculture.

The other major achievements of FFDAs has been the generation of interest in the financial institutions for provision of increased institutional credit for fish farming activity in the country. Since the fishery extension cannot be successful without a free flow of credit, the phenomenal success of fishery extension service under the FFDA in a majority of the States could be
attributed to this. It is also creditable that the country has been able to utilize the World Bank Aid of US $ 19.34 million both for fish seed production and promotion of fish farming in the rural areas through Fish Farmers' Development Agencies (FFDAs). The project was designed to increase carp production in five states (Bihar, Madhya Pradesh, Orissa, Uttar Pradesh and West Bengal) through construction of public fish seed hatcheries, improvement of fish ponds, strengthening of fisheries extension services, establishment of training centres and provision of technical assistance. National Bank for Agriculture and Rural Development (NABARD) provide assistance to fishery sector both Inland and Marine. In the recent years they have enhanced allocation to cater loans.

Tremendous advancement have been made in the recent past in aquaculture technologies to achieve very high rates of fin fish and shell fish production. For example, about 10-24 t/ha/year of carps from still water ponds in India and aerated ponds in China as against the traditional production of 300-900 kg/ha/year. Japan and Indonesia have developed intensive culture of common carp yielding over 50-200 kg/m²/6 months whereas Thailand is producing 9-10 kg/m²/4-6 months through Clarias culture. Malaysia and Thailand produce over 2 tonnes of fresh water prawn/ha/year. Taiwan, Indonesia and the Philippines produce over 2-10 t/ha/year of shrimp. Cage culture techniques in different countries with different species of fish show the rate
of production to be about 200-260 kg/m²/year whereas through integrated farming system with livestock many countries have been able to achieve high rate of fish production at 3-7 t/ha/yr. These potential production rates have no match with that from the open sea, river and reservoir which hardly yield 10-15 kg/ha/year (Sinha, 1988).

In the recent past attempts are being made to refine technologies for integrating fish culture with pig and duck farming. In an experiment on fish-cum-pig rearing, a production at the rate of 7300 kg/ha/year of fish was obtained with pig dung as fertiliser, and without any supplementary feeds. In another experiment on fish-cum-duck culture a production of 4323 kg/ha/year was obtained. No supplementary feed was supplied to the fishes nor any fertiliser applied in the pond. Yet, it has been possible to obtain fish production at the rate of 8-9 tonnes/ha/year in duck-cum-fish culture (Sinha, 1988). These experiments have shown promising results in utilising pig dung and duck droppings in fish culture.

Most Asian countries have a shortage of fertiliser, which is a constraint in food production, yet they do not fully recycle wastes. The amount of organic wastes available for recycling in Asia must be prodigious, and if utilised effectively could play a tremendous role in food production. Only the Chinese fully utilise organic wastes including human excreta,
which is collected daily from villages and cities for use in agriculture. Recycling of organic waste in aquaculture has helped in bringing down the on farm production cost benefitting the rural entrepreneur.

Under cultural operations with man's intervention the adding of extraneous nitrogen in the form of manure, fertilizers and feed has brought about experimental production to the extent of 10.2 tonnes/ha/year. Such additional input of nutrients is expected to set in a chain of ecological reactions before the nitrogen is converted into biomass. It is envisaged that this process must be different in a natural pond without the man's interference depicting natural carrying capacity in comparison to those water bodies wherein aquaculture operations are undertaken.

The role of ICAR research institutes in formulating aquaculture technologies have been massive. Alikunhi (1952), Chaudhuri (1960), Banerjee (1967), Bhowmik (1968), Gaudet (1967), Sinha (1972), Dehadrai (1976), Tripathi (1976) have indicated through their studies the behaviour of pond ecology but the information is meagre and have concentrated their observations mainly on fish production. With a view to develop culture technologies, earlier Ganapati (1941), Swingle (1954), George (1962 e & b) have published a number of papers on ecology of various types of water bodies. It is also reported that carrying
capacity of a given water body of one acre is known to sustain a biomass of about 300 lbs. per year under natural conditions (Swingle, 1947). However, the scope of enhancing the productivity through adding extraneous input is tremendous. Nevertheless the critical information on the comparative aspects of natural water bodies in relation to extraneous interference and the inter-relationship of ecological systems in the form of disturbed and undisturbed situations is completely lacking.

Not so much research on the Socio-economics of aquaculture systems has been done. Investigation in these areas provide guideline for decision making among farmers, and also for formulating aquaculture policies. Major Research are:-

- Assessment of Techno-Socio-economic impacts of aquaculture on food production, employment, income and foreign exchange earnings.

- Evaluation of economics of operation in different scales and types of aquaculture management.

- Study of the Social and economic constraints for development of aquaculture.

In order to meet the need for highly qualified and trained manpower to take up the above research programmes, a number of steps have been taken up by the Government, specially by the ICAR. While fisheries faculties of the Agricultural universities shall be training the manpower and the centre of Excellence
in freshwater aquaculture at Central Institute of Freshwater Aquaculture (CIFA) would provide research backup. Research facilities are being upgraded in Central Institute of Fisheries Education (CIFE), Bombay with setting of a number of laboratories, a large number of which will be directly involved in training manpower and taking up research at the highest level to meet the future needs of qualified manpower for aquaculture development.

For development of rural districts, it is essential that research and education centres should be located in production centres and the basic education and training imparted to the farmers. Demonstration farms should also be established in these areas as a supplement to the research centres to establish a proper link between the researchers, aquaculturists and extension service organisation.

With the thrust on rural aquaculture in the country, it is generally seen that ponds in rural areas adopted for fish farming are largely unkept and unmanaged whereas certain progressive farmers follow the practices of conditioning their ponds. As such it becomes imperative to study such representative pond ecosystems on a comparative basis.

In this dissertation an attempt has been made to study the two ponds of different ecological systems at the Fish Farm, Shahdara under Delhi Administration in Delhi Territory. Area
of ponds ($T_1$ and $T_2$) selected is 450 sq. m each 30 m x 15 m). The maximum and minimum depth maintained during the period of study was recorded as 2.15 m and 1.60 m respectively. In the process it was envisaged that one pond ($T_2$) so selected that it remained undisturbed from man's intervention but stocked with judicious density of selected fish population (Indian major carp - catla, Rohu and Mrigla). Whereas the other pond ($T_1$) subjected to a meticulous aquaculture operation to achieve the highest production possible per unit water area. These two ponds were undertaken for detailed study to cover all cycles of operation in a year. The following studies were conducted to understand the comparative behaviour of the selected water bodies:

(i) The topography, agro-climatic conditions and physical properties.

(ii) Physical and chemical parameters such as temperature, pH, Alkalinity, Turbidity, Phosphate, Silicates, Magnesium, and Respiratory gases, such as Oxygen ($O_2$) & Carbon dioxide ($CO_2$).

(iii) The biological parameters such as phytoplankton, zooplankton and fish species in terms of their behaviour, occurrence and growth in terms of the total biomass.

The study has indicated information for characterising the nature of water bodies assessment of their information, mechanism
leading to productivity and basic information on the comparative behaviour of two separate aquatic ecosystems. The information could be of strategic importance in projecting standards for characterising water areas under aquaculture operations in the country and clarify a number of anomalies which have been taken for granted till date in terms of inherent carrying capacity which in my opinion has been reflecting wrongly as of today for benchmark figures in the country. It is also envisaged that a standardised procedure would be evolved for the assessment of the potentials of such water bodies in the country and streamline the concepts of rural aquaculture operations.