UNIT-1

I.1 Definition and History of Aquaculture

What is aquaculture?

"Aquaculture is defined as the cultivation of fishes and other aquatic organisms in natural environments or artificial environments for the purposes of food.Aquaculture is a kind of agriculture in water using advanced technologies.Aquaculture is a branch of fisheries.Fisheries is of two types ,namely capture fisheries and culture fisheries .

"Aquaculture refers to the breeding,rearing,and harvesting of plants and animals in all types of water environments including ponds,rivers,lakes and the ocean"

Capture fisheries is the catching of fishes from the water.Culture fisheries is the cultivation of fishes and other aquatic organisms.it is also called as Aquaculture.

In this regard, it is important to note that currently, aquaculture is not only aimed at food production but also at obtaining bio-active compounds (anti carcinogens, essential fatty acids, proteins, etc.) through the cultivation of macro algae, sea cucumbers, or bio-fuels through the cultivation of micro-algae.

History of Aquaculture

The first aquaculture experiences date back 6,600 years with eel farming; likewise, other research found evidence of carp aquaculture in China in 6200 BC.The first Blue Revolution began 8,000 years ago in China. In 475 BC, Fan Lei wrote the first Aquaculture Treaty where he explained carp farming.The first evidence of some kind of control over the reproduction of Nile tilapia in captivity in irrigation ponds comes from paintings dating back to 1500 BC, found in The ban in Egypt. Likewise, the first evidence of aquaculture practices took place in Asia in 1000 BC, due to the desire of an emperor to have a constant supply of his favorites .The initial forms of aquaculture practiced involved confining wild aquatic animals in lakes, ponds, or small coastal lakes; there is evidence that tilapia was already being farmed in Egypt, and that Japanese, Greeks, and Romans farmed oysters.It was not until the 17th century that artificial breeding began through hatcheries, a practice that is very widespread today. In the 1960s, aquaculture gained greater prominence with the realization that fishing would not guarantee future protein supply, and the use of sea cages for salmon farming, a practice that is one of the most important in the world, grew.

What is the importance of aquaculture?

1. Aquaculture is an important source of proteins, providing essential amino acids that are crucial for human health and development.
2. Fish and other aquatic products are rich in omega-3 fatty acids, vitamins, and minerals, making them a valuable addition to a balanced diet.
3. Aquaculture helps alleviate malnutrition and improve micro nutrient deficiencies, particularly in developing regions.
4. According to Globe-fish, the apparent per capita consumption in 2019 was 20.5 kilograms, of which aquaculture accounts for 11.2 kilograms; in this regard, aquaculture is responsible for more than 50% of the fish and seafood we consume.
5. Aquaculture not only provides food but also plays an important role in producing bio-active compounds (fatty acids, proteins, vitamins, etc.) for the food and pharmaceutical industries, bio fuel production, the recovery of wild species (restocking), education, wastewater treatment, among others.

6. Aquaculture plays a crucial role in reducing pressure on over-exploited wild fisheries. By providing a sustainable alternative source of seafood.
7. Aquaculture helps conserve marine ecosystems and protect biodiversity.
8. As global demand for seafood continues to rise, aquaculture is poised to play an even more significant role in meeting this demand without compromising the health of wild fish populations.
9. Aquaculture solely as a food production activity but as an opportunity to produce a range of substances that can be integrated with other economic activities like agriculture.
10. Aquaculture is a powerful economic driver, especially in rural and coastal areas. The industry generates job opportunities, promotes economic diversification, and contributes to poverty reduction.

Challenges of Aquaculture

Aquaculture, like any human activity, is not without environmental challenges. Pollution caused by aquaculture operations, such as nutrient runoff and escaping fish, can affect water quality and harm ecosystems. Chary (2023) identified six priorities that could make aquaculture more circular:

1. Increasing production and demand for the most essential species,
2. Reducing food loss and waste at farm and post-harvest stages,
3. Supporting nutrient recycling practices on multiple scales,
4. Adapting aquaculture feed formulations,
5. Informing consumers about the benefits of low-trophic level species and other environmentally friendly aquatic foods, and
6. Addressing urgent research gaps.

Types of Aquaculture

Aquaculture can be classified into various production systems depending on the species raised, environmental characteristics, types of facilities, levels of intensification, among other factors. There are four approaches to aquaculture:

"**C**ommercial aquaculture,"

"**C**onservation aquaculture,"

"**R**estorative aquaculture," and

"**R**egenerative aquaculture."

By the environment in which it is practiced

Marine Aquaculture or Mariculture

Marine aquaculture refers to the breeding, rearing, and harvesting of aquatic plants and animals (primarily oysters, clams, mussels, shrimp, salmon, and other marine fish) in water with a salinity of more than 30 practical salinity units (PSU).

Freshwater Aquaculture

This is practiced in inland environments using freshwater. Freshwater is defined as water with less than 0.5 PSU.Freshwater aquaculture refers to the breeding and rearing of aquatic animals (fish, freshwater shrimp, crabs, bivalves, etc.) and native plants using ponds, reservoirs, lakes, rivers, and other inland water bodies.

Brackish Water Aquaculture

Technically, brackish water is a mixture of freshwater and seawater that usually occurs in coastal areas and typically has a salinity between 0.5 and 30 PSU. A characteristic of many surface brackish waters is that their salinity can vary significantly in space and time.

By the level of intensity or production systems

Extensive System

Conducted in ponds where fish feed on the primary production of the water body, which is enhanced by fertilization. These systems have low stocking densities, for example, 1 fish/m², and their yields are less than 500 kilograms per hectare.

Semi-intensive System

Conducted in constructed ponds that are fertilized (organically or chemically) and where animals are given supplementary balanced feed. The density ranges between 1 and 5 fish/m². Aeration is sometimes used, covering about 10 to 15% of the pond area.

Intensive System

Conducted in ponds, cages, raceways, or tanks with constant monitoring of water quality, feeding, and production. Aeration is typically used in at least 50% of the pond area. Feeding depends solely on artificial diets. The density ranges between 5 to 20 fish/m², depending on water exchange and aeration provided to the pond.

Super-intensive or Hyper-intensive System

Primarily conducted in tanks, under strict control of all factors, mainly water quality, aeration, and feeding. The stocking density is over 20 fish/m²; however, the peak production density achieved depends on the ability to maintain good water quality conditions for the cultured organisms.

By Number of Species

Monoculture : A single species is cultivated. For example, tilapia or trout farming.

Polyculture: Two or more species are cultivated in the same pond or system. The most important consideration in polyculture is the potential to increase fish production by better utilizing natural food or the area of the cultivation systems. For example, tilapia and shrimp farming, where tilapia inhabit the water column and shrimp live on the pond bottom.

Integrated Cultures: Organic waste from the cultivation of other animals like ducks or pigs is used to produce microalgae, which in turn feed the fish. Integrated cultures have advanced to concepts like rice-fish farming, biofloc technology, aquaponics, integrated multi-trophic aquaculture (IMTA), and aqua-mimicry.

I.2 Blue Revolution

1. Blue Revolution also called as Neel or Nili Kranti Mission in India was launched in 1985-1990 during the 7th Five-Year Plan.
2. The main objective is to develop, manage, and promote fisheries to double the farmers' income.
3. **Hiralal Chaudhuri and Dr. Arun Krishnsnan** are known as Father of Blue revolution.
4. The Blue Revolution in India was launched by Fish Farmers Development Agency (FFDA) by the Central Government of India.
5. Blue Revolution, the Neel Kranti Mission has the vision to achieve economic prosperity of the country and the fishers and fish farmers.

Introduction to the Blue Revolution

The Blue Revolution (Nili Kranti) is an initiative taken by the government for the growth of the aquaculture industry.

It started in China as it accounts for around two-thirds of the total aquaculture production worldwide.

Recently, the aquaculture industry has been growing at an average rate of 9% a year and India is one of the fastest growers.

The Neel Kranti Mission was the start of the Blue Revolution in India with the vision to achieve the economic prosperity of India keeping in view the sustainability, bio-security, and environmental concerns.

Nili Kranti in India

The Blue Revolution in India was launched during the 7th Five Year Plan (1985-1990) during the sponsorship of the Fish Farmers Development Agency (FFDA) by the Central Government of India. Later, during the 8th Five Year Plan (1992-97), the Intensive Marine Fisheries Program was launched, and eventually, the fishing harbours in

Vishakhapatnam, Kochi, Tuticorin, Porbandar, and Port Blair were also established over the time. This scheme focused on the development and management of fisheries controlled by the National Fisheries Development Board (NFDB).

The components that are included under the Blue Revolution Schemes are :

1. National Fisheries Development Board (NFDB) and its activities
2. Strengthening of Database & Geographical Information System of the Fisheries Sector
3. Development of Inland Fisheries and Aquaculture
4. National Scheme of Welfare of Fishermen
5. Development of Marine Fisheries, Infrastructure and Post-Harvest Operations
6. Monitoring, Control and Surveillance (MCS) and other need-based Interventions
7. Institutional Arrangement for the Fisheries Sector

Objectives of the Blue Revolution/Neel Kranti Mission

The Nili Kranti Mission aimed to enhance the economic condition of India through the augmentation of fisheries and thus contributing towards the food and nutritional security. The utilization of the water resources for the development of fisheries was done by the Neel Kranti Mission in a sustainable manner.

The objectives of the Nili Kranti mission are mentioned below:

1. Completely tapping the total fish potential of India on both islands as well as in the marine sector and to triple the production by the year 2020.
2. Transforming the fisheries sector into a modern industry through the utilization of new technologies and processes.
3. Doubling the income of the fishers through increased productivity and improving the post-harvest marketing infrastructure including e-commerce, technologies, and global best innovators.
4. To ensure the active participation of the fishers and the fish farmers in income enhancement.
5. Tripling the export earnings by the year 2020 with a major focus on the benefits covering the institutional mechanisms.
6. Developing the nutritional and food security of the nation.

Features of the Blue Revolution Scheme

Some of the salient features of the Blue Revolution Scheme are:

1. Providing suitable linkages and convergence with the 'Sagarmala Project' of the Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGA), Ministry of Shipping, National Rural Livelihoods Mission (NRLM), Rashtriya Krishi Vikas Yojana (RKVY), etc.
2. The Blue Revolution scheme concentrates mainly on enhancing the production and productivity of aquaculture and fisheries both from the inland and marine sources.
3. Promoting and encouraging the economically backward sections like the Scheduled Castes, Scheduled Tribes, Women, and their co-operatives to take up fishing.
4. The Blue Revolution Scheme also encourages entrepreneurship development, private investment, Public-Private Partnership (PPP), and better leveraging of institutional finance.

Blue Revolution in India – Outcomes

The Blue Revolution in India along with the Fish Farmers Development Agency (FFDA) brought an improvement in the aquaculture and fisheries sector with the introduction of new techniques of rearing, marketing, exporting, and fish breeding.

Some of the major outcomes of the Blue Revolution in India are mentioned below:

1. Currently, the Indian Fisheries Sector reached a production of 4.7 million tonnes of fish including 1.6 million tonnes of fish from freshwater aquaculture from a limit of 60,000 tonnes (50 years ago)

2. India is recorded to achieve an average annual growth of 14.8% as compared to the global average percentage of 7.5 in the production of fish and fish products.
3. The fishery has become India's largest agricultural export over the last five years with a growth rate of 6-10%.
4. India has become the world's second-largest producer of fish with exports worth more than 47,000 crore rupees.
5. The fisheries and aquaculture production contributes 1% and 5% to India's GDP and Agricultural GDP respectively.

PRADHAN MANTRI MATSYA SAMPADA YOJANA (PMMSY):

Vision :

Ecologically healthy, economically viable and socially inclusive fisheries sector that contributes towards economic prosperity and well-being of fishers, and fish farmers and other stakeholders, food and nutritional security of the country in a sustainable and responsible manner.

INTRODUCTION

The PMMSY is designed to address critical gaps in fish production and productivity, quality, technology, post- harvest infrastructure and management, modernisation and strengthening of value chain, traceability, establishing a robust fisheries management framework and fishers" welfare.

The PMMSY is an umbrella scheme with two separate components namely

(a) Central Sector Scheme (CS) and

(b) Centrally Sponsored Scheme (CSS).

The Centrally Sponsored Scheme (CSS) Component is further segregated into Non-beneficiary oriented and beneficiary orientated components/activities under the following three broad heads:

(i) Enhancement of Production and Productivity

(ii)Infrastructure and Post-harvest Management Fisheries Management and Regulatory Framework subPradhan Mantri Matsya Sampada has been approved at a total estimated investment of Rs. 20,050 crores comprising of Central share of Rs. 9407 crores, State share of Rs 4880 crores and Beneficiaries contribution of Rs. 5763 crores.

PMMSY will be implemented in all the States and Union Territories for a period of 5(five) years from FY 2020 -21 to FY 2024-25.

AIMS AND OBJECTIVES (PMMSY) are:

1. Harnessing of fisheries potential in a sustainable, responsible, inclusive and equitable manner.
2. Enhancing of fish production and productivity through expansion, intensification, diversification and productive utilization of land and water.
3. Modernizing and strengthening of value chain - post-harvest management and quality improvement.
4. Doubling fishers and fish farmers' incomes and generation of employment.
5. Enhancing contribution to Agriculture GVA and exports
6. Social, physical and economic security for fishers and fish farmers.

The PMMSY would be implemented through the following agencies:

(i) Central Government and its entities including National Fisheries Development Board
(ii) State/UT Governments and their entities
(iii) State Fisheries Development Boards
(iv) Any other End Implementing Agencies as decided by Department of Fisheries

PMMSY targets :

- Fish production is likely to be enhanced from 13.75 million metric tons (2018-19) to 22 million metric tons by 2024-25.

- A sustained average annual growth of about 9% in fish production is expected.
- An increase in the contribution of GVA of the fishing sector to the Agriculture GVA from 7.28% in
- 2018-19 to about 9% by 2024-25.
- Double export earnings from the present Rs.46,589 crores (2018-19) to about Rs.1,00,000 crores by 2024-25.
- Enhancement of productivity in aquaculture from the present national average of 3 tons to about 5
- tons per hectare.
- Reduction of post-harvest losses from the reported 20-25% to about 10%.
- Doubling of incomes of fishers and fish farmers.
- Generation of about 15 lakhs direct gainful employment opportunities and thrice the number as
- indirect employment opportunities along the supply and value chain.
- Enhancement of the domestic fish consumption from about 5 kg to about 12 kg per capita.
- Encouragement of private investment and facilitation of growth of entrepreneurship in the fisheries sector.

I.3 Present status of Aquaculture – Global and National scenario

- ✓ India is the second largest fish producing country in the world with the current estimated fish production of 14.73 million metric tonnes during 2020-21.
- ✓ It contributes 7.56 % of global production.Fish and fish products have presently emerged as one of the largest groups in agricultural exports of India with 13.77 lakh tonnes in terms of quantity and Rs. 45,106.89 crore in value The fishery sector in India (culture and capture fisheries combined) contributes 5.23% to the Gross Domestic Production (GDP) of the agriculture sector and 1.07 % to the total GDP of the country.
- ✓ Fisheries and aquaculture provide employment to more than 43 million individuals worldwide. In India, Fisheries and aquaculture provide gainful employment and livelihood support to more than 28 million people by engaging them in different fisheries and related activities Fisheries in India is a very important economic activity and a flourishing sector with varied resources and potentials.
- ✓ There is a 20–fold increase that India achieved in fish production in just six decades, i.e. from 0.75 million tonnes in 1950-51 to 14.73 million tonnes during 2020–21.
- ✓ This made India the second Largest country in the world after China in aquaculture production. Freshwater aquaculture showed an overwhelming ten-fold growth from 0.37 million tonnes in 1980 to 4.03 million tonnes in 2010; The freshwater aquaculture comprises of the culture of carp fishes, culture of catfishes (air breathing and non-air breathing), culture of freshwater prawns, culture of pangasius, and culture of tilapia. The three Indian major carps, namely catla (Catla catla), rohu (Labeo rohita) and mrigal (Cirrhinus mrigala) contribute the bulk of production to the extent of 70 to 75 percent of the total fresh water fish production.
- ✓ Catfishes forming a second important group contributing the balance of 25 to 30 percent. It is estimated that only about 40 percent of the available area of 2.36 million hectares of ponds and tanks has been put to use and an immense scope for expansion of area exists under freshwater aquaculture In addition, in brackishwater sector, the aquaculture includes culture of shrimp varieties mainly, the native giant tiger prawn (Penaeus monodon) and exotic whitelegshrimp (Penaeus vannamei).
- ✓ The national mean production levels from still water ponds has gone up from about 600 kg/hectare/year in 1974 to over 2900 kg/hectare/annum at present and several farmers are even demonstrating higher production levels of 8–12 tonnes/hectare/year.
- ✓ The technologies of induced carp breeding and polyculture in static ponds and tanks virtually revolutionized the freshwater aquaculture sector and turned the sector into a fast growing commercial sector. The

freshwater prawn farming has received increased attention only in the last two decades due to its high consumer demand.

- ✓ The giant river prawn, Macrobrachium rosenbergii, the largest and fastest growing prawn species, is cultured either under monoculture or polyculture with major carps. Culture for mariculture species has been initiated in the country and is presently carried out to a limited extent for seaweeds, and mussels as a commercial activity and some fish species like seabass and cobia on an experimental basis to standardize the technology.
- ✓ In addition, there is contribution from cold water fisheries. They constitute about 1% of total fish production. Important food fishes of cold waters are tor tor, mahaseer etc. India has an estimated total estuarine area of 3.9 million hectares; Of this, about 15 percent of the potential area has been put into aquaculture purpose. Apart from the giant tiger prawn (P. monodon), certain marine/brackish water fish/shrimp species such as milkfish, pearl-spot and mullets have shown a lot of promises for commercial aquaculture India's aquaculture production basically can be classified into freshwater and brackish water production. Some of the important species cultured in India are the Indian major carps and shrimp.
- ✓ Besides these, ornamental fish culture and seaweed farming, are slowly gaining importance. Induced breeding of carps and catfishes helped in the rapid growth of aquaculture. Production of 4–5 tonnes under carp polyculture is quite common, farmers of several regions are able to produce 8–12 tonnes/ha/year. Integrated fish farming with livestock and horticulture has not only been able to utilize the by products/wastes as principal inputs, but also made the farming practice highly remunerative and farmers' friendly.
- ✓ Development of genitically improved rohu (Jayanti) through selective breeding with a record of 17 percent higher growth is a mile stone in indian carp industry.
- ✓ Availability of balanced supplementary feed for different life stages for various organisms also paved the way for the strengthning of this field.
- ✓ Mariculture in India, although limited to the farming of mussels and edible oysters undertaken in some coastal region of Kerala over the years, has successfully produced sea cage farming in recent years, initially with sea-bass and most recently cobia, which has shown the prospects of commercial mariculture in the country.

Indian Fisheries

Global position	3rd in Fisheries , 2nd in Aquaculture
Contribution of Fisheries to GDP (%) India 2021	1.07
Per capita fish availability (Kg.)	9.0
Employment in sector (million)	28.0

Resources

Coastline	8118 kms
Exclusive Economic Zone	2.02 million sq. km
Continental Shelf	0.530 million sq. km
Rivers and Canals	1,95,210 km
Reservoirs	3.150 million ha
Ponds and Tanks	2.414 million ha
Flood Plains lakes and derelict waters	0.798 million ha
Brackishwaters	1.240 million ha
Estuaries	0.290 million ha

Andhrapradesh fisheries

Andhra Pradesh has been contributing significantly to the fish basket of the country in the recent years through an effective strategy in both coastal and freshwater aquaculture and marketing. The state has 5.17 lakh ha of freshwater ponds and tanks, 11,514 km of rivers and canals, 4.58 lakh ha of reservoirs and 150,000 ha of water areas suitable for coastal aquaculture. The inland fish production is 6.8 lakh tonnes, with the mean yield of pond aquaculture is around 3.5 tonnes/ha/year, above the national average. Further, by virtue of its 974 km long coastline, the state produces 2.97 lakh tonnes of marine fish annually.

Some Facts

Present fish Production (Capture)	7.0 million metric tons
Inland	3.2 mmt
Marine	3.8 mmt
Potential fish production	8.4 mmts
Fish seed production	40,000 million fry
Hatcheries	1,604 units

I.4 Agriculture vs Aquaculture

Agriculture focuses on land-based farming and cultivation of crops, while aquaculture centers around the cultivation of aquatic organisms.

Agriculture majors gain expertise in soil science, plant breeding, and pest management, while aquaculture majors delve into fish nutrition, water quality management, and aquaculture production systems.

Both majors require a strong foundation in biology and chemistry.

Agriculture career opportunities include agricultural engineer, crop consultant, farm manager, and agricultural economist, while aquaculture career opportunities include aquaculture technician, fish farm manager, seafood quality assurance specialist, and aquaculture researcher.

Agriculture	**Aquaculture**
Crop Science	Fish and Shellfish Biology
Soil Science	Aquaculture Systems
Animal Science	Water Quality and Management
Agricultural Economics	Aquatic Ecology
Agribusiness Management	Aquatic Health and Disease

Similarities	**Agriculture**	**Aquaculture**
Resource use	Land, water, and energy	Water and energy
Environmental impact	Soil erosion, water pollution	Water pollution, habitat destruction
Economic importance	Employment opportunities, food production	Employment opportunities, food production

Both agriculture and aquaculture require the careful management of resources such as land, water, and energy. They also share common environmental concerns, including pollution and habitat destruction. Additionally, both industries play a significant role in providing employment opportunities and meeting the growing demand for food.