Introduction to Aquaculture.

Aquaculture is fish farming. It is the art and science of controlled rearing of fish in ponds, farms and in some instances natural water bodies from hatchlings to matured size. It involves the farming of fish, crustaceans, molluscs, aquatic plants, algae, and other organisms. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish Unlike fish that grow in the wild water bodies, without human interference, in aquaculture, activities such as feeding, fertilization, stocking, reproduction and harvesting are controlled. Aquaculture is been defined as an industrial process of raising aquatic organisms up to final commercial production within properly partitioned aquatic areas, controlling the environmental factors and administering the life history of the organism positively and it has to be considered as an independent industry from the fisheries hitherto. Aquaculture is organised production of a crop in the aquatic medium. The crop may be that of an animal or a plant. Naturally, the organism cultured has to be ordained by nature as aquatic.

Aquaculture in other terms is also known as **aquafarming**. Mariculture commonly known as marine farming refers to aquaculture practiced in marine environments and in underwater habitats, opposed to in freshwater. According to the Food and Agriculture Organization (FAO), aquaculture "is understood to mean the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated."

Particular kinds of aquaculture include fish farming, shrimp farming, oyster farming, mariculture, algaculture (such as seaweed farming), and the cultivation of ornamental fish. Particular methods include aquaponics and integrated multi-trophic aquaculture, both of which integrate fish farming and aquatic plant farming. The Food and Agriculture Organization describes aquaculture as one of the industries most directly affected by climate change and its impacts. Some forms of aquaculture, such as seaweed farming, have the opportunity to be part of climate change mitigation, while other forms of aquaculture have negative impacts on the environment, such as through nutrient pollution or disease transfer to wild populations.

Examples are:

Finfish: Tilapia, carp, trout, milkfish, bait minnow, yellow tail, mullet, cat fish.

Shellfish: Shrimps, prawns, oysters, mussels, pearl oyster for cultured pearls (eg. Japanese pearl oyster, *Pinctada fucata*).

Plants: Water chestnut (*Trapa natans*). Red alga, "Norie" (*Porphyra*), (*Eucheuma*) Brown alga, "Wakame" (*Undaria*), Microalgae, also referred to as phytoplankton, microphytes, or planktonic algae etc.

Aims of Aquaculture

i. Production of protein rich, nutritive, palatable and easily digestible human food benefiting the whole society through plentiful food supplies at low or reasonable cost.

ii. Providing new species and strengthening stocks of existing fish in natural and man-made water-bodies through artificial recruitment and transplantation.

iii. Production of sportfish and support to recreational fishing.

iv. Production of bait-fish for commercial and sport fishery.

v. Production of ornamental fish for aesthetic appeal.

vi. Recycling of organic waste of human and livestock origin.

vii. Land and aquatic resource utilization: this constitutes the macroeconomic point of view benefiting the whole society.

It involves

(a) maximum resource allocation to aquaculture and its optimal utilization;
(b) increasing standard of living by maximizing profitability; and
(c) creation of production surplus for export (earning foreign exchange especially important to most developing countries).

viii. Providing means of sustenance and earning livelihood and monetary profit through commercial and industrial aquaculture. This constitutes the micro-economic point of view benefiting the producer. In the case of small-scale producer, the objective is to maximize income by greatest possible difference between income and production cost and, in the case of large-scale producer, by maximizing return on investment.

ix. Production of industrial fish.

Types of Aquaculture

The different kinds of aquaculture are:

i. Static water ponds.
ii. Running water culture.
iii. Culture in recirculating systems: in reconditioned water and in closed systems.
iv. Culture in rice fields.
v. Aquaculture in raceways, cages pens and enclosures
vi. Finfish-culture cum livestock rearing.
vii. Hanging, „on-bottom" and stick methods of oyster culture.
Based on the number of species that are cultured in a system aquaculture may be classified into:
(a) Monoculture and
(b) Polyculture.

(a) Static freshwater ponds

Ordinary fresh water fish culture ponds are still-water ponds. They vary a great deal in water spread area and depth. Some are seasonal and some perennial. The ponds may be rainfed (also called sky ponds) and/or may have inlet and outlet systems. The water supply may be from a stream or a canal or from an underground source such as wells, tube wells etc.

(b) Running water culture

At places where there is abundant supply of water, common carp is cultured in running water ponds. The most intensive common carp is cultured in running water ponds.

(c) Culture in recirculatory systems

This system is comparable to running water culture system except that in the latter, water goes waste whereas here the same water is reused. In this system, water is filtered continuously and recirculated, often after aeration, to the fish pond. The filtering element is a biological filter comprising 3 – 4 cm diameter pebbles, or honey-comb synthetic strips, designed to arrest faecal matter and to denitrify catabolic wastes through bacterial action.

(d) Culture in Rice Fields

Culturing fish and growing rice together in the same paddy fields is an old practice. Interest in producing rice and fish together had declined in recent years because of use of fish-toxic pesticides required to protect high yielding varieties of rice introduced as part of green revolution.

(e) Aquaculture in Raceways: Cages, Pens and Enclosures

Marine aquaculture farms may be located at six possible sites either on the shore with pumped sea-water supply; in the intertidal zone; in the sublittoral zone, or offshore with surface floating, mid-water floating or seabed cages.

(f) Finfish Culture-cum-Livestock Rearing

This is a synergic system of mutual benefit to each organism cultured: duck droppings manuring the pond, duck foraging consuming a variety of unwanted biota for fish culture such as tadpoles, frogs, mosquito and dragonfly larvae, molluscs, aquatic weeds etc.

(g) Monoculture.

Monoculture, as the name implies is the culture of a single species of an organism in a culture system of any intensity, be it in any type of water, fresh, brackish or salt e.g.,
Fresh water: Catfish, Clarias gariepinus in Africa, *Tilapia nilotica* in Kenya

(h) Polyculture.

Polyculture, as the name implies, is the culture of several species in the same waterbody. The culture system generally depends on natural food of a waterbody sometime augmented artificially by fertilization and/or by supplementary feeding. If artificial food is given it is a common food acceptable to all or most species that are cultured. e.g., Fresh water:
Polyculture of *Clarias gariepinus* and tilapias in Africa.

Harvest stagnation in wild fisheries and overexploitation of popular marine species, combined with a growing demand for high-quality protein, encouraged aqua-culturists to domesticate other marine species.

Domesticating aquatic species involves fewer risks to humans than do land animals, which took a large toll in human lives. Most major human diseases originated in domesticated animals, including diseases such as smallpox and diphtheria, that like most infectious diseases, move to humans from animals. No human pathogens of comparable virulence have yet emerged from marine species. Biological control methods to manage parasites are already being used, such as cleaner fish (e.g., lumpsuckers and wrasse) to control sea lice populations

in salmon farming. Models are being used to help with spatial planning and siting of fish farms in order to minimize impact. The decline in wild fish stocks has increased the demand for farmed fish. However, finding alternative sources of protein and oil for fish feed is necessary so the aquaculture industry can grow sustainably; otherwise, it represents a great risk for the over-exploitation of forage fish.

Aquatic plants

Microalgae, also referred to as phytoplankton, microphytes, or planktonic algae, constitute the majority of cultivated algae. Macroalgae commonly known as seaweed also have many commercial and industrial uses, but due to their size and specific requirements, they are not easily cultivated on a large scale and are most often taken in the wild.

Seaweed farming

Seaweed farming or kelp farming is the practice of cultivating and harvesting seaweed. In its simplest form, it consists of the management of naturally found batches. In its most advanced form, it consists of fully controlling the life cycle of the algae.

Fish

The farming of fish is the most common form of aquaculture. It involves raising fish commercially in tanks, fish ponds, or ocean enclosures, usually for food. A facility that releases juvenile fish into the wild for recreational fishing or to supplement a species' natural numbers is generally referred to as a fish hatchery. Worldwide, the most important fish species used in fish farming are, in order, carp, salmon, tilapia, and catfish.

A similar process is used in the salmon-farming section of this industry; juveniles are taken from hatcheries and a variety of methods are used to aid them in their maturation. For example, as stated above, some of the most important fish species in the industry, salmon, can be grown using a cage system. This is done by having netted cages, preferably in open water that has a strong flow, and feeding the salmon a special food mixture that aids their growth. This process allows for year-round growth of the fish, thus a higher harvest during the correct seasons. An additional method, known sometimes as sea ranching, has also been used within the industry. Sea ranching involves raising fish in a hatchery for a brief time and

then releasing them into marine waters for further development, whereupon the fish are recaptured when they have matured.

Aquacultural methods

Mariculture

Mariculture refers to the cultivation of marine organisms in seawater, usually in sheltered coastal or offshore waters. The farming of marine fish is an example of mariculture, and so also is the farming of marine crustaceans (such as shrimp), mollusks (such as oysters), and seaweed. Channel catfish (*Ictalurus punctatus*), hard clams (*Mercenaria mercenaria*) and Atlantic salmon (*Salmo salar*) are also prominent in mariculture.

Mariculture may consist of raising the organisms on or in artificial enclosures such as in floating netted enclosures for salmon and on racks for oysters. In the case of enclosed salmon, they are fed by the operators; oysters on racks filter feed on naturally available food. Abalone have been farmed on an artificial reef consuming seaweed which grows naturally on the reef units.

Integrated multi-trophic aquaculture

Integrated multi-trophic aquaculture (IMTA) is a practice in which the by-products (wastes) from one species are recycled to become inputs (fertilizers, food) for another. Fed aquaculture (for example, fish, shrimp) is combined with inorganic extractive and organic extractive (for example, shellfish) aquaculture to create balanced systems for environmental sustainability (bio mitigation), economic stability (product diversification and risk reduction) and social acceptability (better management practices).

"Multi-trophic" refers to the incorporation of species from different trophic or nutritional levels in the same system. This is one potential distinction from the age-old practice of aquatic polyculture, which could simply be the co-culture of different fish species from the same trophic level. In this case, these organisms may all share the same biological and chemical processes, with few synergistic benefits, which could potentially lead to significant shifts in the ecosystem.

Sometimes the term "integrated aquaculture" is used to describe the integration of monocultures through water transfer. For all intents and purposes, however, the terms "IMTA" and "integrated aquaculture" differ only in their degree of descriptiveness. Aquaponics, fractionated aquaculture, integrated agriculture-aquaculture systems, integrated peri-urban-aquaculture systems, and integrated fisheries-aquaculture systems are other variations of the IMTA concept.

Netting materials

Various materials, including nylon, polyester, polypropylene, polyethylene, plastic-coated welded wire, rubber, galvanized steel and copper are used for netting in aquaculture fish enclosures around the world. All of these materials are selected for a variety of reasons, including design feasibility, material strength, cost, and corrosion resistance.

Recently, copper alloys have become important netting materials in aquaculture because they are antimicrobial (i.e., they destroy bacteria, viruses, fungi, algae, and other microbes) and they therefore prevent biofouling (i.e., the undesirable accumulation, adhesion, and growth of microorganisms, plants, algae, tubeworms, barnacles, molluscs, and other organisms). By inhibiting microbial growth, copper alloy aquaculture cages avoid costly net changes that are necessary with other materials. The resistance of organism growth on copper alloy nets also provides a cleaner and healthier environment for farmed fish to grow and thrive.

REFERENCE

1. Food and Agriculture Organization (FAO) - https://en.wikipedia.org/wiki/Food_and_Agriculture_Organization http://www.fao.org

2. Lawson T.B. (1995) Aquaculture in open Systems. In: Fundamentals of Aquacultural Engineering. Springer, Boston, MA. https://doi.org/10.1007/978-1-4613-0479-1_5

3. *"Global Annual Mean Surface Air Temperature Change". NASA. Retrieved 23 February 2020*. https://data.giss.nasa.gov/gistemp/graphs_v4/

4. BOYD, C. E. (1982) Water Quality Management for Pond Fish Culture. Developments in Aquaculture and Fisheries Science, Vol. 9. Elsevier, Amsterdam, The Netherlands.

5. *Irons, Robert (July 2019). The Fundamental Principles of Finance. Google Books: Routledge. ISBN 9781000024357. Retrieved 3 April 2021.*

6. *Aquaculture: Environmental, toxicological, and health issues*

   David W.Cole RichardCole Steven J.Gaydos JonGray GregHyland Mark L.Jacques NicolePowell-Dunford CharuSawhneyWilliam

7. *Pal, M. & Morgan, D.L. (2019). "Lates calcarifer". IUCN Red List of Threatened Species. 2019: e.T166627A1139469. doi:10.2305/IUCN.UK.2019-3.RLTS.T166627A1139469.en. Retrieved 22 February 2020.*