Background, Global trend and Types of Mariculture

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Introduction

Fisheries and aquaculture are important sources for food and livelihoods for more than one billion people in the world. The waterways and oceans cover about two thirds of the surface of the earth and it forms the most underutilised natural resource when it comes to food production. The fact that aquaculture is the world's fastest growing food production technology indicates not only that one has started to exploit this potential but also if man succeeds in using the oceans more efficiently, aquaculture can be the largest single contributor to less pressure on land.

Background

Aquaculture is distinguished from other aquatic production such as fishing by the degree of human intervention and control that is possible (Anderson 2002). The production process in aquaculture is determined by biological, technological, economic, and environmental factors. However, the key factor is that many aspects of the production process can be brought under human control. This control makes innovation possible and is, accordingly, essential for the rapid technological development that has fuelled production growth since the early 1970s. As defined by the United Nations Food and Agriculture Organization (FAO), aquaculture is the "farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies intervention in the rearing process to enhance production, like stocking, feeding, security measures etc. The advent of aquaculture dates back millennia, though its exact origins are unknown and a large proportion of organisms that humans rely on for protein and sustenance come from the sea. Currently, approximately 16% of the animal protein consumed by the world's population is derived from fish, and over one billion people worldwide depend on fish as their main source of animal protein.

In the 1970s, what is sometimes labelled as the "blue revolution" began as humanity's accumulated knowledge of aquaculture allowed for the introduction of semi-intensive and intensive farming practices. As a result, producers were able to influence the growing conditions of the fish through feeding, breeding, and so forth, and the production cycle was closed for an increasing number of species. The increasing control of the production process enabled a number of productivity-enhancing innovations to take place. Improved productivity resulted in a reduction in production costs, and with a given price, this led to more profitable production. A number of species are being farmed in all parts of the world, in freshwater and in saltwater. Moreover, a number of different production techniques are being used, adapted to different species, environments, and economic conditions. These techniques include ponds, pens, raceways, ropes, cages, tanks, and closed circulation systems.

Trends in aquaculture

While the growth potential for wild fisheries is limited, it is vast for aquaculture. Aquaculture is a production technology with its origin in Egypt and China thousands of years ago. Beginning in the 1970s, a significant change took place as better control over the production process enabled to develop a number of new technologies and production practices. These changes dramatically improved the competitiveness of aquaculture products both as sources of basic food and as cash crops. The combined effect of productivity and market growth has made aquaculture the world's fastest growing animal-based food sector of the last decades (OECD, 2010).

The species produced in aquaculture is almost as large as in wild fisheries. Aquaculture production includes kelp (seaweed), mussels, crustaceans, carps, tilapia, salmon, seabass, shrimp etc. While aquaculture has been a success in terms of increased production, it also faces strong opposition in many countries because the new technologies that are enabling the increased aquaculture production are interacting negatively with the environment. There are numerous examples of unsustainable as well as sustainable aquacul-

ture practices. It is of the highest importance to encourage sustainable practices and discourage ruining of locations and causing negative impacts on the environment.

Production

Aquaculture is a truly global production technology, with about 180 countries reporting some level of production. However, there are substantial regional differences. Asia makes up about 92% of the production measured by volume and 79.6% by value. All the other regions have a higher value than volume share, because they produce high value products especially South America. China is by far the largest producer country, with a value share of more than 50% and a volume share of 70%. Measured by value, India, Chile, Vietnam, Japan, Norway, Indonesia, Thailand, Burma, and South Korea are the other top 10 producing countries. Egypt is the largest producer in Africa and is ranked number 13. Aquaculture is clearly strongest in Southeast Asia and is primarily conducted in developing countries.

The total supply of seafood increased from 69.0 million tonnes in 1976 to 142 million tonnes in 2008 (FAO, 2011). Hence, the availability of seafood has more than doubled during this period. Seafood appears from two main modes of production – harvest and aquaculture, and the development of production in total capture and culture production since 1970 is shown in Fig.1. Until the 1970s, though aquaculture was not very important, a virtual revolution has taken place since then. In 1970 aquaculture production was still rather miniscule with a produced quantity of about 3.5 million tonnes, representing 5.1% of total seafood supply. In 2006, it was made up to 41.8% with a production of 66.7 million tonnes. The increased production in aquaculture is accordingly the only reason why global seafood supply has continued to increase since 1990. Stimulated by higher demand for fish, world fisheries and aquaculture production is projected to reach about 172 million tonnes in 2021, with most of the growth coming from aquaculture. Aquaculture will remain one of the fastest-growing animal food-producing sectors (SOFIA, 2012). The aquaculture production from 2006 is given below:

Aquaculture Production (Million tonnes; FAO, 2012)

	2006	2007	2008	2009	2010	2011
Inland	31.3	33.4	36.0	38.1	41.7	44.3
Marine	16.0	16.6	16.9	17.6	18.1	19.3

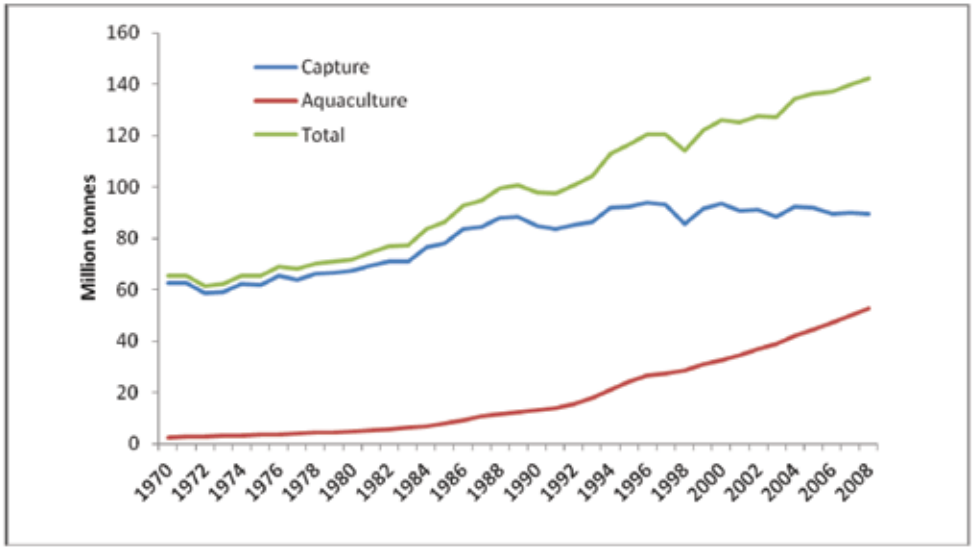

Fig.1. Development of fisheries production in total capture and culture production since 1970 (Source: FAO)

The world mariculture production is like; Molluscs (23.6 %, 14.2 million tonnes); Crustaceans (9.6 %, 5.7 million tonnes); Diadromous fishes (6.0 %, 3.6 million tonnes) and Marine fishes (3.1 %, 1.8 million tonnes) with a total of 29.2 million tonnes.

Salmons represent the largest diadromous fish species group, with an average growth rate of 5.5% per year over the last decade. Trouts represent the second-largest diadromous fish species group, with an average growth rate of 3.5% per year over the last decade. Milkfish represent the third-largest diadromous aquaculture species, with species production growing at an average rate of 4.7% per year over the last decade. Eels represent the fourth-largest diadromous aquaculture species group, with species group production growing at an average rate of 2.8 % per year over the last decade. Marine fishes represent the last major fish species group by production, with species group production growing at an average rate of 8.1 % per year over the last decade. Marine shrimps represent the largest crustacean species group, with species group production growing at an average rate of 14.7% per year over the last decade (FAO, 2010).

The major cultured fish and crustacean are:

Marine crustaceans: 3.64 million tonnes, valued at US$15.0 billion

- Shrimps – 3.40 million tonnes, six major spp.
- Crabs – 241 000 tonnes; one major species

Diadromous fishes: 3.26 million tonnes, valued at US$12.95 billion

- Salmons – 1.57 million tonnes, two major spp.
- Trouts – 677 000 tonnes, one major sp.
- Milkfish Chanos chanos – 676 000 tonnes
- Eels – 265 000 tonnes, one major sp.
- Miscellaneous diadromous fish species – 71 000 tonnes; one major sp.

Marine fishes: 1.77 million tonnes, valued at US$6.6 billion:

- Seabass – 214 000 tonnes, two major spp.
- Mullets – 235 000 tonnes, one major spp.
- Porgies, seabreams – 253 000 tonnes, two major spp.
- Jacks, crevalles – 184 000 tonnes, one major sp.
- Flounders, halibuts, soles – 149 000 tonnes, two major spp.
- Croakers, drums – 123 000 tonnes, two major spp.
- Groupers – 78 000 tonnes;
- Cods, hakes, haddocks – 21 387 tonnes, one major species;
- Tunas, bonitos, billfishes – 8 926 tonnes, one major species; and
- Miscellaneous marine fish species – 499 000 tonnes, three major species

On a global basis, more than 85.5% of fish and crustacean aquaculture production was produced in the Asian continent in 2008 (26.9 million tonnes), followed by the Americas (1.93 million tonnes, or 6.1%), Europe (1.64 million tonnes, or 5.2%), Africa (0.94 million tonnes, or 3.0%), and Oceania (50 317 tonnes, or 0.2%; FAO, 2010a). Twenty countries accounted for 94 % of total global fed fish

Country	Production (million tonnes)	Percent of total production
China	15.67	49.8
India	3.08	9.8
Viet Nam	2.12	6.7
Indonesia	1.64	5.2
Thailand	1.03	3.3
Norway	0.84	2.7
Philippines	0.70	2.2
Egypt	0.69	2.2
Myanmar	0.65	2.1
Chile	0.63	2.0
Bangladesh	0.62	2.0
United States	0.34	1.1
Japan	0.30	1.0
Brazil	0.27	0.8
Taiwan Province of China	0.22	-
Ecuador	0.17	-
Malaysia	0.17	-
Turkey	0.15	-
Mexico	0.14	-
United Kingdom	0.14	-

and crustacean production in 2008, with China alone accounting for about half of the global total (Table). These top 20 fed species producers were also the largest consumers and producers of feed, either in the form of fresh feeds, farm-made feeds or commercial feeds.

What matters for the development of aquaculture is the degree of control of the production process. It is this control that enables innovation and systematic gathering of knowledge that creates further growth. As such, it is the transition from extensive to semi-intensive farming in Southeast Asia, and in particular the feeding of the fish, that is the most important factor for the growth in aquaculture production. As species with highly intensive production systems lead the way, the production process is likely to become even more intensive in most places.

Types of mariculture

Mariculture of a new species typically starts by catching wild juveniles and feeding them in a controlled environment. As more knowledge is gained, the degree of control with the production process increases and the farmers can increase their influence on growth and reproduction. The degree of control is often categorised by the intensity of the aquaculture operation. Traditional aquaculture varies between extensive and semi-intensive farming practices. Mussel farming is an example of an extensive method used around the globe, whereby the farmer provides a rope or a stake for the mussel fry to fasten to and undertakes some culling so that the density does not get too high, but otherwise leaves the mussels to grow without further interference. The small ponds used in Chinese aquaculture were traditionally operated on an extensive basis, because the farmer did little to control growth and biomass. In intensive aquaculture, the production system is closed so that one does not depend on wild fish for reproduction.

Aquaculture production systems and practices, by region (Source: FAO)

Region	Major Culture Species	Major Culture Systems	Major Culture Practices	Scope for Future Development/Needs for Further Expansion
ASIA	At least 75 species; diverse freshwater and marine species, including high-value shrimps, molluscs, seaweeds, with carps and seaweeds dominating production	Traditional extensive to intensive	Fish ponds Fish pens and fish cages Floating rafts, lines, and stakes for molluscs and seaweeds	Development of culture-based fisheries in inland lakes, rivers, floodplains, and permanent and temporary reservoirs and barrages
				Resource enhancement programmes integrated with environmental management
PACIFIC	Mussels and oysters, red seaweeds	Intensive/semi-intensive to extensive	Hanging lines for mussels and pearl oysters	Production of high-value species for select markets;
			Offshore cages for salmon	Small-scale aquaculture for local markets;
			Pond culture for shrimps, tilapia, catfish, milkfish	Improved management of fishery resources, particularly reef fisheries
			Freshwater pens for crayfish	
LATIN AMERICA	50 species of fish, crustaceans, and molluscs, including freshwater fish and marine shrimps in South America and molluscs in Central America	Extensive to semi-intensive and Intensive	Offshore cage farming of Pacific and Atlantic salmon Ocean ranching in Southern Ocean Semi-intensive farming of marine shrimp in coastal ponds	Production of species for export and marine shrimp and salmon
MEDITERR-ANEAN	most important being salmonids and oysters and mussels	Well-diversified modern practices, with highly technical and intensive systems in developing countries and semi-intensive and extensive elsewhere	- Fish cages - Ocean ranching	Production of high-value species of tourism and export Integrated coastal zone management
CARIBBEAN	marine shrimp and oysters and seaweeds		Floating cages in reservoirs	Priority is for aquaculture production for local markets
			Rope production of molluscs	

- Marine Ponds are mainly for growing prawns and some finfishes either by tide fed systems or by pumping in off seawater at periodic intervals.
- Tank farming (Prawn broodstock tanks; Prawn culture tanks; Barramundi): Some species grow well in tanks which are aerated and have a continuous exchange of water to keep the dissolved oxygen levels high and remove wastes
- Sea Cage farming (Salmon, Tuna; Snapper, Barramundi, grouper):
- Long Line farming (Pearl oysters, Mussels): It uses a series of floats arranged in a row. The long-line is secured at each end with two anchors. One long-line is 100 m long and consists of about 51 floats connected by a polyurethane rope 15 mm in diameter. A series of strings of oysters called "rens", each about 5m long is attached to each rope
- Raceway farming (Abalone; Oysters; Algae; Barramundi): Raceways are usually large concrete tanks; generally 30 m long, 3 to 10 m wide and 1 m deep and usually have higher flow rates than ponds.
- Fish hatcheries: Fish hatcheries are used to breed a large number of fish in an enclosed protected environment. Such an environment greatly increases the chances of survival of the fish fry. Many hatcheries then sell the juvenile fish for release into the ocean (e.g. into sea cages).
- Polyculture and integrated aquaculture: Polyculture and integrated aquaculture are methods of raising diverse organisms within the same farming system, where each species utilizes a distinct niche and distinct resources within the farming complex (Figure 2).39 This may involve the rearing of several aquatic organisms together or it could involve raising aquatic organisms in conjunction with terrestrial plants and/or animals. In either case, the wastes from one organism are used as inputs to another, resulting in the optimal use of resources and less pollution overall. Polyculture systems can provide mutual benefits to the organisms reared by creating symbiotic relationships while allowing for a balanced use of the available aquatic resources, whereas intensive monoculture systems extract resources from the system and place more stress on the surrounding environment. In addition, integrated systems can increase the economic efficiency of fish farms through improved conversion rates of input materials.41 Polyculture and integrated aquaculture have the potential to address some of the problems that arise from the intensive rearing of single finfish species. For example, the integration of fish culture with the culture of algal and/or shellfish species shows potential for reducing the risks of eutrophication and also for exploitation of the large amounts of wastes produced by fish farms. Further research is needed however, to determine the effectiveness of such systems, especially in open marine environments.

Closed and low discharge systems

Recirculating systems: Concerns for water conservation and reduced waste discharges have prompted the increased use of closed recirculating aquaculture systems. Recirculating systems generally consist of land-based tanks with constantly flowing water. The systems are made up of three basic components: culture chamber, settling chamber, and biological filter. Water enters the culture chamber, flows through the settling chamber and then moves through the biological filter to remove additional particulate matter. The water is then circulated back through the systems' culture chambers. Recirculating systems conserve water and allow producers to control all of the environmental factors that might affect their plants and animals. For example, aquaculturists have complete control over temperature, salinity, oxygen, predators and introduction and transfer of diseases. Recirculating systems, however, can be costly to operate, as they are highly dependent on electricity or other power sources. Pumps must be used in order to maintain the constant flow of water and often water must be heated or cooled to the desired temperature. Recirculating systems have less of an impact upon the environment because of their closed nature – wastes and uneaten feed are not simply released into the ambient environment in the manner that they are with net pens and exotic species and diseases are not introduced into the environment. In recirculating systems, wastes are filtered out of the culture system and disposed of in a responsible manner. Recirculating systems can be built just about

anywhere, including in urban settings where they can use existing structures and be placed close to markets, thereby reducing transportation costs. Recirculating systems can be used to grow a wide variety of fish species year-round in controlled environments.

Conclusion:

Maldives with a coastline of 644 km, by initiating mariculture with minimum inputs in the country can contribute to the economy as well and establish it in the near future with production of quality products within and outside the country.