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INTEGRATED MULTI-TROPHIC AQUACULTURE

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Population around the world face question of food security today on a scale that has not been seen in recent human history. The evolution of how we feed our population and the technologies we use to do it have created a unique set of circumstances that bring with them unique challenges, and despite significant advances in food production and our knowledge of food nutrition and food safety, hunger continuous to million of people around the world. It is thought that over a billion people in the world are currently undernourished (World Food Programme, 2010). At present the world's greatest challenges – how to feed more than 9 billion people by 2050 in a context of climate change, economic and financial uncertainty, and growing competition for natural resources. Global fish production is estimated to have reached about 179 million tones in 2018 with a total first sale value estimated at USD 401 billion. Aquaculture accounted for 46 percent of the total production. Shrimp aquaculture feed represents about 60% of operating cost and the major ingredient of formulated feeds has been fish meal derived from the smaller pelagic fisheries. Further, it was reported that more than 50% of formulated feed remain unused and thus the profitability of monoculture and sustainability are directly linked. Brackish water aquaculture in India is nearly synonymous with monoculture of shrimp and this system is more vulnerable to volatility both in production and prices. Further, the more a system is managed to take maximum yield, it would become less resilient and more vulnerable to abiotic and biotic shock. Therefore, diversification of systems and species used for culture are considered to be the key elements to strengthen the resilience to food production system and its sustainability. The Integrated multi-trophic aquaculture (IMTA) involving fed species with organic extractive species and Inorganic extractive species that utilize wastes from aquaculture for their growth. IMTA systems can be land-based or open-water systems such as marine or freshwater systems, and may comprise several species combinations. Some IMTA systems have included such combinations as shellfish/shrimp, fish/seaweed/shellfish, fish/shrimp and sea-weed/ shrimp. IMTA is considered more sustainable than the common monoculture systems – that is a system of aquaculture where only one species is cultured in that fed monocultures tend to have an impact on their local environments due to their dependence of supplementation with an exogenous source of food and energy without mitigation. Integration of different species in one culture unit can reduce these impacts because the culture of the species that do not require exogenous feeding may balance the system outputs through energy conversion, whereby the waste of one species becomes the food for another.

The importance of IMTA as a management option for sustainable ecosystem functions along with economic benefits has been recognized recently. Brackish water aquaculture has not developed in many states on the west coast (Kerala, Karnataka, Goa, Maharashtra and Gujarat) as in the case of east coast of India, even though aquaculture potential in these states is high. Maharashtra has ~80000 ha of brackish water area of which ~12445 ha are suitable for aquaculture with an annual production of only ~7000 tone of shrimp.

Definition

IMTA is the farming of aquaculture species from different trophic levels and with complementary ecosystem functions, in a way that allows one species uneaten feed and wastes, nutrients and byproducts to be recaptured and converted into fertilizer, feed and energy for the other crops, and to take advantage of synergistic interactions between species. This system is entirely different from the 'Polyculture.' To the aims of IMTA is "To ecologically engineer system for environmental sustainability, economic sustainability and societal sustainability. Recent study about IMTA by Barrington (2009) is the practice which combines the cultivation of fed aquaculture species (e.g. shellfish/herbivorous fish) and inorganic extractive aquaculture species (e.g. seaweed) too create balanced system for environmental sustainability (bio-mitigation) economic stability (product diversification and risk reduction) and social acceptability (better management practices). In the Polyculture system fish share the same bio and chemical process which could eventually lead to shift in ecosystem.

Principal of IMTA

IMTA is based on principle "The solution to nitrification is not dilution but extraction and conversion through diversification." IMTA promotes economic and environmental sustainability by converting byproducts and uneaten feed from fed organisms into harvestable crops, thereby reducing eutrophication, and increasing economic diversification.

System Design for IMTA

An IMTA operation needed the selection and placement of various types of components or species. The system design should be engineered to optimize the recapture of waste products. As larger organic particles, such as uneaten feed and faces settle down the cage system, they are eaten by deposit feeders, like sea cucumbers and sea urchins. At the same time, the fine suspended particles are filtered out of the water column by filter-feeding animals like mussels, oysters and scallops. The seaweeds are placed a little farther away from the site in the direction of water flow so they can remove some of the inorganic dissolved nutrient from the water, like nitrogen and phosphorus. In simple meaning of this system the main component is fed aquaculture species is eat some type of food after that release some gases and this some gases used by inorganic extractive aquaculture species, this system is IMTA system. IMTA species should be economically viable as aquaculture products, and densities that optimize the uptake and use of waste material throughout the production cycle.

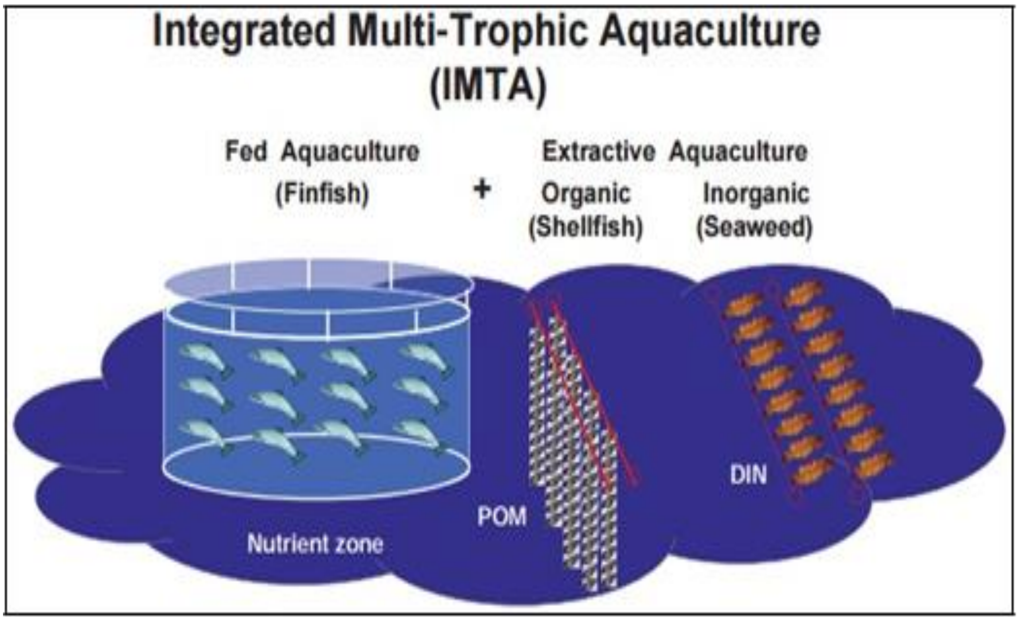

Fig.- Conceptual diagram of an integrated multi-trophic aquaculture (IMTA) operation combining fed aquaculture (finfish) with organic extractive aquaculture (shellfish), taking advantage of the enrichment in particulate organic matter (POM), and inorganic extractive aquaculture (seaweeds), taking advantage of the enrichment in dissolved inorganic nutrients (DIN).

Criteria for selection of fish :

The following important criteria for selection of fish in IMTA system:-

1) Adaptation to tropical environment.
2) Acceptance to all types of feed like natural and artificial feed.
3) Amiability to live together.
4) Compatibility.
5) High Market demand.
6) High market prices.

Appropriate steps should be taken in the IMTA. They are as follows:

- Establishing the economic and environmental value of IMTA systems and their co-products.
- Selecting the right species, appropriate to the habitat, available technologies, and the environmental and oceanographic conditions, complementary in their ecosystem functions, growing to a significant biomass for efficient bio-mitigation, and for which the commercialization will not generate insurmountable regulatory hurdles.
- Promoting effective government legislation/regulations and incentives to facilitate the development of IMTA practices and the commercialization of IMTA products.
- Recognizing the benefits of IMTA and educating stakeholders about this practice.
- Establishing the R&D&C continuum for IMTA.

Taking all these factors into account, IMTA can be used as a valuable tool towards building a sustainable aquaculture industry. IMTA systems can be environmentally responsible, profitable and sources of employment in coastal regions for any country that develops them properly, especially when government, industry, academia, communities and environmental non-governmental organizations work in consultation with each other.

Fish Feed

Fish are largely respond well to natural and commercial fish feed. Their diets need to be well balanced in terms of amino acids, proteins, fats, vitamins, minerals and carbohydrates etc. in order to achieve good growth and survivability.

Advantages of IMTA

- Effluent bio-mitigation:- The mitigation of effluents through the use of bio-filters (e.g. seaweeds and invertebrates), which are suited to the ecological niche of the farm.
- Disease control:- Prevention or reduction of disease among farmed fish can be provided by certain seaweeds due to their antibacterial activity against fish pathogenic bacteria or by shellfish reducing the virulence of ISAV (Infectious salmon anaemia virus).
- Increased profits through diversification:- Increased overall economic value of an operation from the commercial by-products that are cultivated and sold.
- Increased profits through obtaining premium prices:- Potential for differentiation of the IMTA products through eco-labeling or organic certification programs.
- Improving local economy:- Economic growth through employment (both direct and indirect) and product processing and distribution.
- Form of ‘natural’ crop insurance:- Product diversification may offer financial protection and decrease economic risks when price fluctuations occur, or if one of the crops is lost to disease or inclement weather.

Disadvantages of IMTA

- Lower productivity than fed monocultures.
- Food safety concerns (coliforms and parasites).
- Public perception issues.
- Species limitations (especially in New Zealand).
- Requires good management to balance inputs and nutrient flows.

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