Ecosystem Approach to Brackishwater Aquaculture (EABA),
A Sustainable Model in Aquafarming and its Relevance to Coastal Aquaculture of Kerala*

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Aquaculture is increasingly recognized as the best option to meet the growing demand for food requirements of the ever increasing population across the world (Costa-Pierce, 2002). Although it has been traditionally practiced in many Asian countries, modern aquaculture is a relatively recent enterprise in most of the region where it is currently being practiced. Since 1980s, in many tropical developing countries, there was a drive towards non traditional high valued export oriented agriculture crops (Hall, 2004). Modern brackishwater aquaculture in India, more specifically shrimp aquaculture, is the paradigmatic example for such crops. The growth of brackishwater shrimp aquaculture in India has been spectacular, and production of farmed shrimp in India has risen from about 20 mt in 1970 to 2, 69,500 mt in 2012 (FAO 2014). During the initial phase of the modern aquaculture, it was considered as benign form of agriculture, and most aquaculturists strongly believed that they are environmentalists (Stickney, 2002). But later aquaculture was branded as detrimental to the environment, although many of the criticism are based on perceived problems. While acknowledging the economic gains and employment opportunities provided by the brackishwater aquaculture sector, it is essential to recognize that the growth of brackishwater aquaculture in India is skewed towards monoculture of shrimp.

As aquaculture grows, it is inevitable to face confronting challenges (for example, issues of diseases, wild fish meal utilization), which are too complex to resolve at individual business or even at country level (Chamberlein, 2014). Undoubtedly, aquaculture will expand further, and it has to be, but question is: How? What are the potential environmental and social consequences, and how can we mitigate them? what is the way forward? In order to ensure social acceptance and long term sustainability aquaculture needs family and community roots, and aquaculture must be planned as a part of broader ecosystem perspective (Costa-Pierce 2002). This form of aquaculture would eventually leads into a “blue revolution”. This blue revolution is not a modern clone of green revolution that require high inputs of fossil-fuel inputs to sustain high production levels, but an evolution incorporating the knowledge process of 21 st century, that ensure the social equity and environmental sustainability (Costa-Pierce 2002). In order to provide an unambiguous linkage among aquaculture, environment and society, and to promote the complementary role of aquaculture, an ecosystem approach to aquaculture is needed. Ecosystem approach to aquaculture (EAA) *is a strategy for the integration of the activity within the wider ecosystem in such a way that it promotes sustainable development, equity, and resilience of interlinked social and ecological systems"* (Soto et al., 2007). The present article mainly aims to provide an overview of ecosystem approach to aquaculture, its principle, conceptual frame work and relevance to Indian brackishwater aquaculture context. The first part of the review summarizes the principles of EAA, followed by a review of present status of Indian brackishwater farming. Further it compiles actual ecosystem based farming practices in India, past and ongoing; and it also provides additional compilation of research results towards this direction.

Genesis of Ecosystem approach to Aquaculture (EAA)

In 2006, Fisheries and aquaculture department of FAO recognized the need of development of ecosystem based management for aquaculture similar to the code of conduct for responsible fisheries. FAO suggested three objectives for the ecosystem approach of aquaculture: human well being, ecological well being and ability to achieve these by effective governance, and these can be measured at farm, region and global level. EAA is defined as "a strategy for the integration of aquaculture with the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked social-ecological systems". EAA is a strategy for the sustainable development and it is guided by three interlinked principles (Soto, 2007). These there principles are operated at three levels, farm level, watershed or region level and globe level (Figure 1).

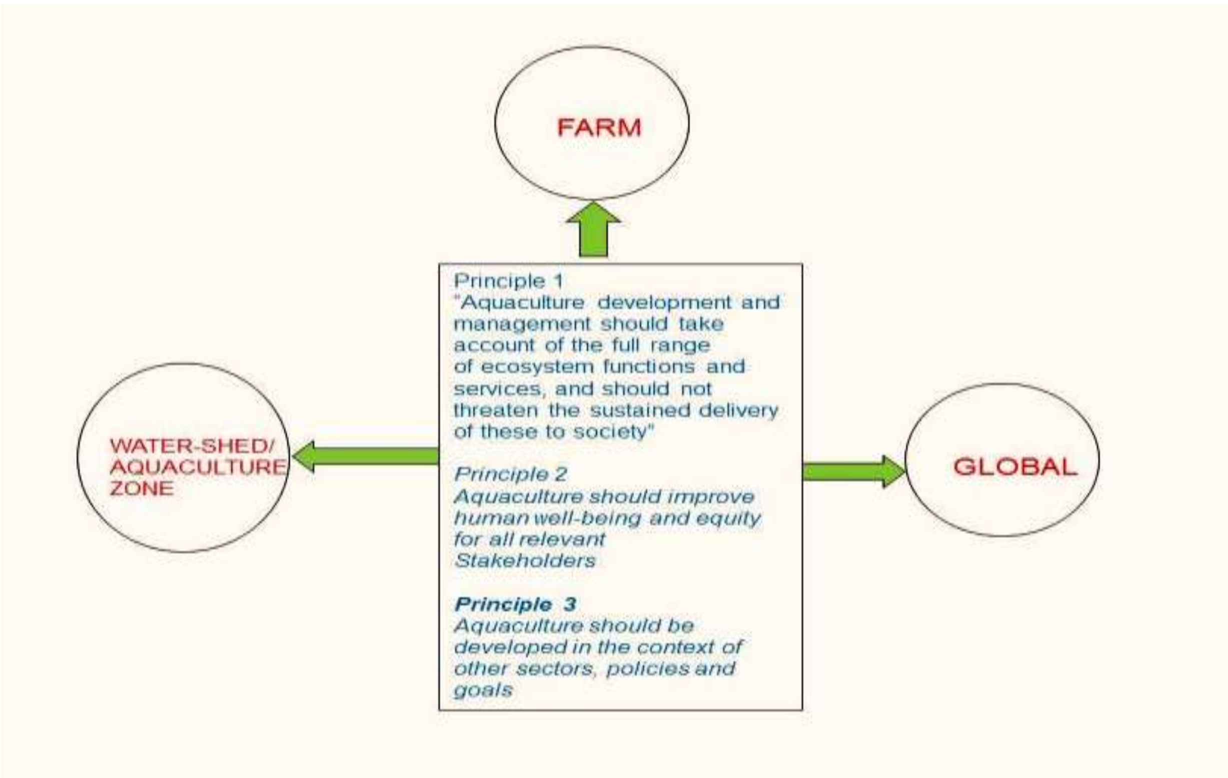

Figure 1: Ecosystem approach to aquaculture: guiding principles and scales.

These three principles are:

Principle 1 *"Aquaculture development and management should take account of the full range of ecosystem functions and services, and should not threaten the sustained delivery of these to society"*

Development of aquaculture within the acceptable limits of environmental variable requires an understanding about the carrying capacity of the ecosystem and ecosystem functioning. The production system whether it is a pond or cage is the 'aquaculture ecosystem' and the ecosystem where this production system is embedded is the wider ecosystem. It may be coastal ecosystem in the case of brackishwater ponds and cages. The resilient or carrying capacity of this ecosystem should be defined

Principle 2 *Aquaculture should improve human well-being and equity for all relevant Stakeholders*

Aquaculture should promote food security and environmental safety. Here food security does not suggest that it should solve the problems of hunger, particularly area where aquaculture is a new activity. However, it should be promote livelihood and generate employment opportunity. Aquaculture development should ensure that it benefits are properly shared among all the stakeholders, from

Principle 3 *Aquaculture should be developed in the context of other sectors, policies and goals*

This principle acknowledge the opportunity of integrating or linking aquaculture with other producing sector to promote material and energy recycling and optimal use of resources. Aquaculture does not take place in isolation, although its impact to other human activities is rather lesser than agriculture and industry.

These three principles are applied at three spatial scales: Farm scale, water shed or aquaculture region scale and global scale. In the following section the description each scale and how guiding principles can be applied are given

Farm scale:

Principle 1. Aquaculture should be developed in the context of ecosystem function

Farm is the basic level and easy to delineate from the ecosystem, and all farm level management for optimizing the production and minimize the environmental risks are included here. For example Better/best management practises based on the 'best available science', bio-security protocol for each species of culture etc. Escape of the cultured species and horizontal transmission of disease to the other farms and wild. The adoption of multi-trophic aquaculture is one of the option to effectively utilize all the ecological niches and recycling of the wastes.

Principle 2. Aquaculture should improve human well-being and equity for relevant stakeholders

Aquaculture offer livelihood option and promote employment opportunities at farm level, contributing to the social wellbeing.

Principle 3. Aquaculture should be developed in the context of other sectors.

Integrating aquaculture with other sectors such as agriculture and animal husbandry would minimize the conflicts between other users of the resources, and plays an inclusive role through maximising the local biological and social ecosystem.

Watershed or aquaculture zone scale.

Principle 1. Aquaculture should be developed in the context of ecosystem function.

The second level or scales, where EAA principles should be applied are watershed or aquaculture zone. This scale is more relevant to social/economic and political issues. Further, clusters of farms using same water resource for the intake and release of effluent causes deterioration of water quality of the common watershed and it causes epidemic outbreak. Escape of farmed organism, particularly alien species would causes detrimental effect to the biodiversity.

Principle 2. Aquaculture should improve human well-being and equity for relevant stakeholders

Several stakeholders will share same watershed or aquaculture zone, and these stakeholders have different capacity and ability. The well planned policy formulation should be taken to provide equity

Principle 3. Aquaculture should be developed in the context of other sectors

Integrated and multi-trophic aquaculture should be planned.

Global scale

Principle 1. Aquaculture should be developed in the context of ecosystem function

Increasing pressure on small pelagic fishes for fish meal industry is one of the most criticized adverse effects on ecosystem. Development of alternative to fish meal is one of the high priority issues

Principle 2 Aquaculture should improve human well-being and equity for relevant stakeholders

Improving the well-being of relevant stakeholders within the context of trans-national aspect of production, and market is a challenge. Development of global opportunities can compromise regional and local opportunities. Aquaculture could act as a feeder into the local economy, through employment generation, local market etc.

Principle 3 Aquaculture should be developed in the context of other sectors

Aquatic proteins are increasing in the diet of world population as the role played by the fish as a healthy food and PUFA source. Therefore aquaculture is rapidly increasing its relevance, by meeting the demand for fish, when the production through fishing is satiated. Opportunities for the producing alternative source of protein from other sectors such as agriculture for replacing fish meal (for example: soya) is increasing. Here aquaculture is acting as a driver for the promotion of an agriculture crop such as Soyabean.

Present status of brackishwater aquaculture in India, and the application of EABA

Owing to the high export market demand from overseas, penaeid shrimp has become the focus of aquaculture development in India, and is almost the face of the Indian coastal aquaculture. Production of farmed shrimp in India has risen from about 20 mt in 1970 to 2, 69,500 mt in 2012 (FAO 2014). It is supposed to be evolved at large from fisheries (capture fisheries *per se*) as a fishery based aquaculture. The fishery based aquaculture is a transition or intermediary phase, which eventually should be developed into a full-fledged aquaculture. In this, farmer either depends on wild seeds or hatchery produced seeds from wild caught brooders, also supplemented with formulated feed. Later traditional locality based aquaculture has evolved into an organised farm based aquaculture, and Indian shrimp aquaculture is a paradigmatic example of such development. Although modern aquaculture enterprise has been criticized for its unsustainable way of development, it is the mainstay of growth of aquaculture, due to economic reasons

Brackishwater resources in India

Brackishwater is meant that the water in which the salinity is appreciable but not to a constant high level. It is usually characterized by daily and seasonal fluctuations in salinity (0.5 to 30 ppt), due to freshwater and full strength marine water influxes. Enclosed coastal and inland water bodies in which the salinity is greater than the freshwater but less than the marine water also regarded as brackishwater. Indian coastal areas have nine states, two island territories with a coastline of 7516.6 km. It has 97 major estuaries with a total area of 3.9 million ha and backwaters of 3.5 million ha. The total mangrove area is 6740 km^2 and of these 57% of mangrove ecosystem are at east coast and 23% are at west coast, and 20% are at Andaman and Nicobar islands. Vast stretches Inland saline areas are also available.

Among the coastal brackishwater ecosystem about 1.2 million ha has been identified as potentially suitable for brackishwater aquaculture whereas only 0.15 million ha (12.7%) where developed for shrimp or brackishwater aquaculture (Chandrasekaran et al, 2003). West Bengal and Gujarat have the majority of the potential area for brackishwater aquaculture owing to the high tidal amplitude (Figure 2). Andhra Pradesh developed almost 50% of area available for shrimp culture where as Maharashtra and Gujarat utilized only 0.5 to 2.5% of the available area. However recently, a vibrant aquaculture sector, especially shrimp farming, is emerging in Gujarat.

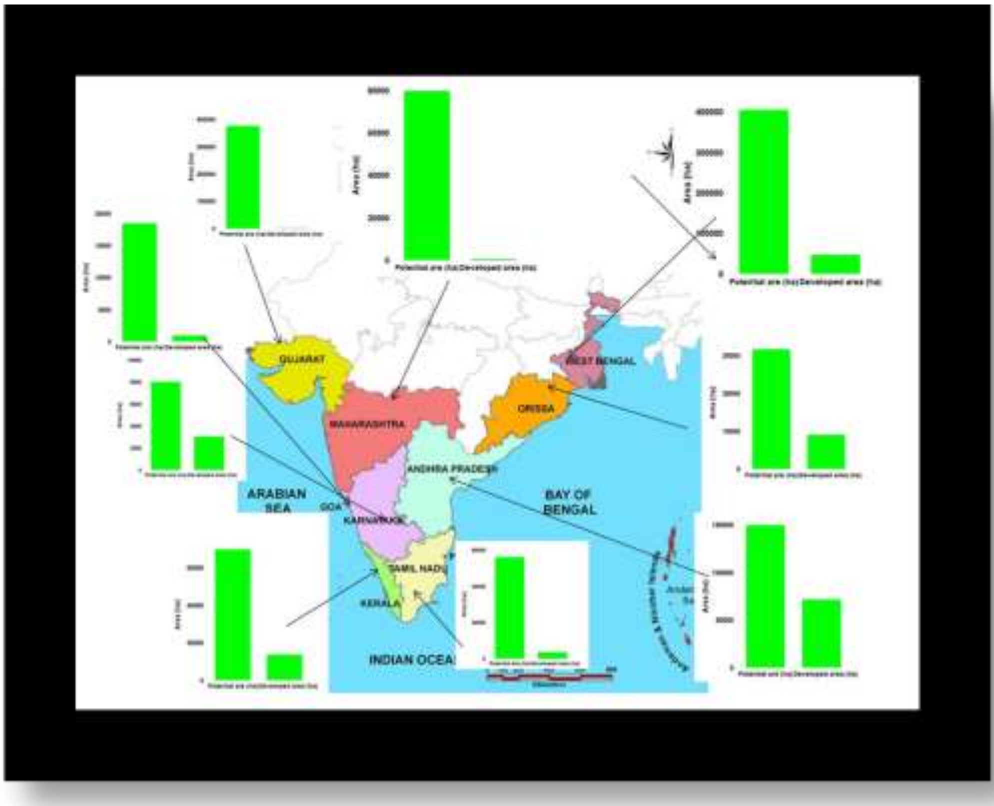

Figure 2: Map of India showing the state wise potential and developed areas for shrimp/brackishwater aquaculture

Production characteristics

The first recorded data for farmed shrimp production in India were 20 mt in 1970 and first major change became obvious in 1991 when it reached 40000 mt. Farmed shrimp production showed a remarkable growth during early 1990s. Rapid growth of shrimp aquaculture induced an increase in farming area (Table 1) from 65000 ha in 1990, to @ 0.16 million ha in 1999, later it has been reduced to @ 0.12 ha in 2013-2014. Major reduction in area under farming was recorded in Andhra Pradesh mainly due to disease problems and related crop failures, where the farmed area reduced from 85000 ha in 1999 to 36000 ha in 2013-2014, whereas West Bengal and Gujarat showed marginal increase. However, Andra Pradesh still contributed more than half of the farmed shrimp production in India (Table 2). By early 2000 shrimp production also increased up to 100000 mt in 2001. This growth occurred in spite of the set back caused by white spot syndrome virus (WSSV) in the later part of nineties, since 1994. The disease impacted aquaculture industry severely, and it caused the exit of almost all corporate investors by 1997. A recovery and moderate growth happened in the post WSSV era, from 2000 to 2006 shrimp farming gradually increased and peaked with a maximum production of about 1.4 lakh tonnes in 2006, but production reduced drastically in 2008. Again, 2000-2011 witnessed a remarkable upsurge of farmed shrimp, due to the introduction of the exotic American shrimp, *Litopenaeus vannamei*, resulting in an increased production of about 1,25,000 tonnes in 2012-13 (Figure 3).

Table 1- Areas under shrimp cultivation by state

State	**1990**	**1994**	**1999**	**2014**
West Bengal	33815	34400	42525	48,410
Orissa	7075	8500	11332	6,302
Andhra Pradesh	6000	34500	84269	36,123
Tamil Nadu	250	2000	2670	7,804
Kerala	13000	14100	14595	12,917
Karnataka	2500	3500	3540	394
Goa	525	600	650	31
Maharashtra	1800	2400	970	1,486
Gujarat	125	700	997	2,359
Total	**65090**	**100700**	**161548**	**1,15,826**

Table 2: Area under farming, production and percent of total production during 2013-14 (MPEDA 2014)

State	**Area under farming**	**Production (mt)**	**Percent of total production**
West Bengal	48,410	52,581	19.4
Orissa	6,302	14,532	5.4
Andra Pradesh	36,123	159,083	58.7
Tamil Nadu	7,804	25,815	9.5
Kerala	12,917	5,175	1.9
Karnataka	394	664	0.2
Goa	31	63	0.02
Maharashtra	1,486	3,513	1.3
Gujarat	2,359	9,393	3.5
Total	115,826	270,819	

Presently, the scenario of Indian brackishwater aquaculture is found to be bright; however, it is certainly not without problems, uncharacterized diseases, problems in the hatchery production, problems due to the pond reared broodstock etc are the challenges of brackishwater aquaculture sector.

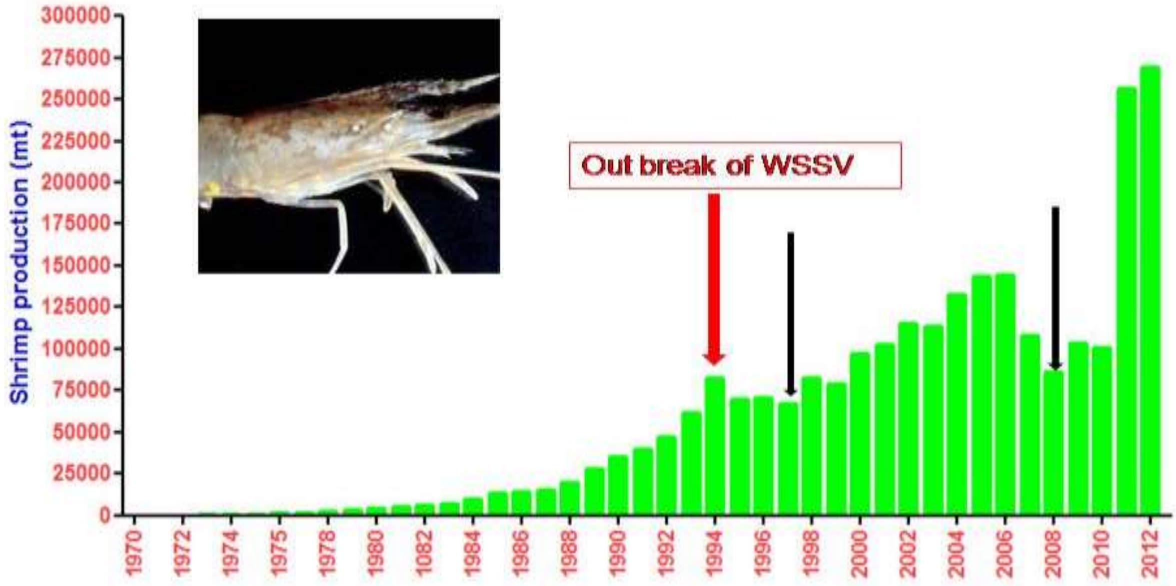

Figure 3: Shrimp production in Indian

In order to make Indian brackishwater aquaculture sector sustainable, and more socially equitable, the adoption of EABA is essential. The subsequent section provides a short overview ecosystem based brackishwater aquaculture in India.

Ecosystem approach to India

EABA, in general, is a strategy for the sustainable development through holistic integrated and participatory process. In India, some of the concept of the principle 1, development of aquaculture considering the full range of ecosystem functions and management has traditionally been practiced in brackishwater aquaculture. Further, there has been research initiation to refine the technique and document the current practices. In this system effluents and residues from the farming system has been recycled and used as resource.

Traditional brackishwater aquaculture system in India

Traditional brackishwater aquaculture prevailing in the coastal states such as Kerala, West Bengal, Karnataka and Goa are classical examples of integrated aquaculture, essentially falls under the framework of EABA. There are two systems of integrated aquaculture: 1. Simultaneous integration of rice and fish culture and 2. Temporal integration of rice with shrimp. These practices have been considered to be ancient practices in coastal belt of Kerala. This traditional poly culture integrated with paddy is a classical example for the optimal utilization of ecosystem function and services. In this type of system, tall, salt tolerant rice varieties are cultured during the monsoon season (summer monsoon: June to Nov) in the fields bordering the backwaters of Kerala, and during the post monsoon and summer season shrimps are cultivated (mainly by auto stocking by the influent waters during the high tide), and these systems have been practising for several decades prior to the advent of modern shrimp culture.

Fig 4 : Rice-Fish Integrated farming from Kerala: Source Rajendran 2012

During the rainy season when salinity was negligible, rice and brackishwater fishes are cultivated in a spatially integrated fashion as these fields are continuously inundated and, peripheral canals have been used for the fish culture. For the cultivation, chemical fertilizers or pesticides are not used. During the harvest, only rice ear heads are harvested, the paddy stubbles are decayed and provide a natural niche of microbiome and planktonic forage organisms for the subsequent shrimp crop. Cost of rice production under this system is generally lower than the cost of production in other rice ecosystem, as the crop is completely devoid of chemical fertilizers and pesticides.

Fig 5. Paddy-cum fish farming; from sunderbans, West Bengal

Table 3: Cultivation expenditure, gross returns and net returns in different integrated systems

Farming systems	Cultivation expenditure (Rs/ ha)			Total	Returns (Rs/ha)	Net returns (Rs/ha)
	Rice	Fish	Shrimp			
Rice alone	2290 0			22900	45344	11976
Rice and fish	2290 0	1250 0		35400	62692	27292
Rice and fish followed by shrimp	2290 0	1250 0	58000	93400	190180	96780

Table 4: Comparison of production and economic returns in the experimental polyculture system (mullet-tiger shrimp. milk fish-tiger shirmp; Biswas et alt 2012)

Parameter	Mullet-tiger shrimp	Milk fish tiger shrimp
Total production (kg/ha)	689 (496 and 193 for mullet and shrimp respectively)	721557 and 164 (for milk fish and shrimp respectively)
Total expenditure (Rs)	8016	6721
Net income (Rs)	2316	1768
Benefit cost ratio	1.20	1.26

Table 3 provides the economic returns of rice-fish/shrimp integrated system, and it indicates that rice and fish followed by shrimp provides significantly high economic returns. More over the cost of fish integration will not cost much. Today these practices still exist in several coastal states of India, particularly Kerala and West Bengal, proving the sustainability of this ecosystem based practice. Presently, many traditional brackishwater farmers practice improved farming methods including hatchery reared seeds, use of organic fertilizers, use of supplementary feeding etc. The recent research also attempts to use improved saline tolerant rice varieties to circumvent the low productivity of traditional rice varieties, to enable increased economic returns to the farmer (Sashidharam, et al 2012). In Kerala initiatives have already been taken to refine and revive the traditional paddy-cum shrimp aquaculture by integrating cultivation of finfishes (e. g. mullet and pearl-spot) in iron cages. After eight months of culture, finfishes provided an income of Rs 80,000 in addition to the income of Rs 50 000 from paddy and shrimp. This system is particularly attractive to farmers. As this practice does not use any chemical inputs, it is purely organic. It is also worth to note that pokkali systems in Kerala received geographical indication certificate (GI) approved logo for its products. This provides further possibility for obtaining a premium price for the products (Anonymous, 2013). Within the frame work of this EABA system, the potential for further improvement are high. The availability of hatchery production of penaeid shrimps and fin fishes such as sea bass, pearl spot and increasing knowledge about this ecosystem provides an opportunity to optimize the sustainability and economic viability of this type of farming practices.

Sequential integration is the form of poly culture where the effluent/ treatment pond are used for the culture of secondary crops, for example fin fishes, bivalves and sea weeds. This form of novel integration is primary for improving the water quality of shrimp ponds and secondarily for generating the additional income. Though widespread practices have not been reported so far, anecdotal evidences indicate that some farmers attempted this practice, and the interest is growing.

Fig 6: IMTA at Kakdwipan Sunderbans, West Bengal

Research efforts

Central Institute of brackishwater aquaculture carried out several experiments to evaluate the production potential of poly culture of brackishwater fin fishes and shell fishes. In an experiment to evaluate the poly culture in an extensive system, farm level performance of two systems evaluated: shrimp with mullets (*Mugil cephalus*, *Liza prasia* and *L. tade*), and shrimp milk fish (*Chanos chanos*). In the 180 day culture experiments, it was found that the production is similar in both systems, however, tiger shrimp out performed in mullet-shrimp system than the milk fish shrimp system (Table 4; Biswas, 2012). It indicates that the mullet is more compatible with shrimp than milk fish. Further, this study concludes that resource poor farmers can adopt this system as the input cost and expenditure is low, and it would be still lower when farmers use on-farm resources. The compatibility of fin fish with shrimp increases the profitability and economic viability of this system.

Carrying capacity

Carrying capacity is the major component of the EABA that helps to set upper limits of aquaculture production within the limits of environment or ecosystem and social acceptability (Ross et al., 2013). It helps to avoid unacceptable changes in the natural ecosystem and social functions. Carrying capacity is defined as "*In general terms, carrying capacity for any sector can be defined as the level of resource use both by humans or animals that can be sustained over the long term by the natural regenerative power of the environment*" (FAO, 2010). As aquaculture expands the areas of culture, inputs such as feed, fertilizers and other resources increase. Aquaculture is a resource based industry, and therefore, it will compete with other allied industries, for example, fisheries, agriculture and tourism. It is therefore, essential to determine the carrying capacity for the sustainable development of aquaculture. Carrying capacity has been categorized into four: physical, production, ecological and social (McKindsey *et al.,* 2006). Physical carrying capacity quantifies the potential area available for aquaculture in the ecosystem. Production carrying capacity estimates the maximum aquaculture production where as ecological carrying capacity determines the magnitude of aquaculture production without leading to the detrimental changes to the ecosystem. Social carrying capacity is the amount of aquaculture that can be developed without major environmental and social impacts.

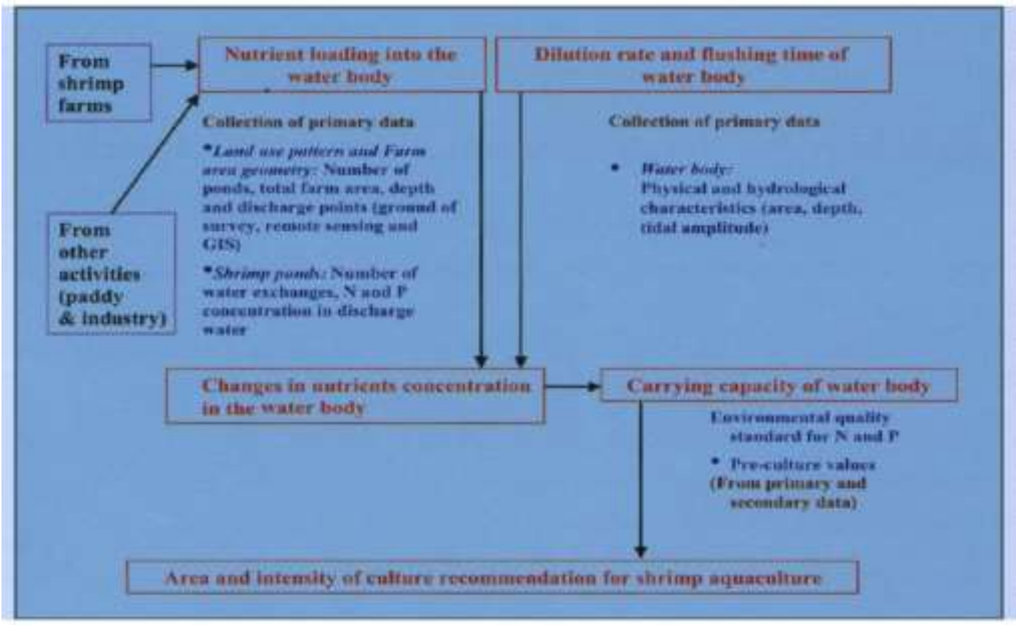

Figure 7: Flow chart for the estimation of carrying capacity

Central Institute of Brackishwater Aquaculture has made pioneer effort to carry out research on the carrying capacity. The institute has developed decision support software in visual basic to estimate the maximum allowable farming area for a particular creek or drainage canal (Muralidhar 2009). The flow chart for the estimation of carrying capacity is given in the Figure 7. This software helps to determine a reliable estimation of impact of shrimp farming and other land use impact in a region under various scenarios of increased development. Further water quality data generated during the project would serve as a baseline data to monitor long term trends in quality of water bodies.

Organic aquaculture

Organic aquaculture is a process of production of aquatic plants and animals with the use of only organic inputs in terms of seeds and supply of nutrients and management of disease following aquatic principles. Organic food production promotes biodiversity; biological cycles and organic farmers aim to manage production as an integrated holistic system. Many of the traditional aquaculture practices in India follow an organic procedure. Organic foods have a separate niche market and many farmers are attracted to these farming practices due to lower cost of production and better economic returns due to the premium price in the market. In India, INDOCERT provides organic aquaculture certification following Natural and certification of Germany. In India, organic aquaculture is in a very nascent stage. However, one good thing is that from ancient time our farmers follow natural way to have the low input culture practice which is otherwise called traditional system of farming and this is close to the organic way of farming. Worldwide more and more species including shrimp farms are certified; and the first few ones includes Ecuador which claims to translate "an aquatic desert to a biodiverse wildlife reserve producing shrimp" and the Ocean Boy Farms in Hendry County. Methods of production eliminate the need for hormones, antibiotics or chemicals to ensure the health of the growing shrimp and the organic certification and "bio-secure environment." is guaranteed.

Organic Aquaculture: Periphyton based farming

CIBA has attempted research effort to enhance the production and sustainability of shrimp farming within the frame work of EABA. Periphyton based farming is an attempt in this direction. Periphyton refers to the entire complex of attached aquatic biota on submerged substrates comprise phytoplankton, zooplankton, benthic organisms and detritus (Figure 8). The study conducted by CIBA (Shyne et al 2013) clearly indicates that periphyton has a beneficial effect of growth and production of shrimp. A better growth rate with a productivity of 1640 to 2796 kg /ha/crop in ponds provided periphyton at a stocking density 8-12 individuals/m^2. Further, the rate of return over operational cost higher in periphyton-based system (92%) compared to the conventional farming (54%). This level of improvement of pond production with cheap on farm resources enhance the productivity of shrimp ponds without deteriorating ecosystem.

Bio-floc based Technology for Brackishwater species:

The concept of delivering high production with sustainability is gaining momentum in aquaculture practices and many technologies like Biofloc technology. "Biofloc" technology is changing the facet of aquaculture with scope to attain high productivity with a sustainable approach. By developing dense heterotrophic bacterial community, the system becomes bacterial dominated rather than algae dominated and takes care of the waste generated in the aquaculture system through in situ bioremediation. It promotes the retention of waste and its conversion to biofloc as a natural food within the aquaculture system. Biofloc is the conglomeration of microorganisms (such as heterotrophic bacteria, algae (dinoflagellates & diatoms), fungi, ciliates, flagellates, rotifers, nematodes, metazoans & detritus). This is a relatively novel biotechnological means to support high density, to maintain the water quality, reduce water exchange, maintaining biosecurity, reutilize the feed and reduce the production cost. There is a need for constant aeration and agitation of the water column and addition of carbon sources as organic matter substrate to allow aerobic decomposition and maintain high levels of microbial floc in suspension in feed and/or fertilized ponds. In a typical brackishwater pond, 20–25% of fed protein is retained in the fish/shrimp, rest is wasted as ammonia and other metabolites, Organic N in feces and feed residue. Increased C:N ratio through carbon addition enhances conversion of toxic inorganic nitrogen species to microbial biomass available as food for culture animals. Microbial flocs produced in suspended growth bioreactors could offer the shrimp industry a novel alternative feed. Now a days biofloc farming system become popular among the shrimp farmers because of its following advantages. The capital costs are most likely higher, but it will pay off in spades with the increased biomass yields with each harvest. CIBA has initiated the efforts to develop a suitable biofloc model suitable for Indian brackishwater farming systems. A series of experiments in pilot scale was conducted at CIBA showed measurable gain in the production as well as FCR in tiger shrimp *P. monodon* farming by following these eco based techniques (Shyne et al. 2012; Shyne et al. 2013). These results also revealed high growth rate in the biofloc system compared to that of the conventional system, and a ability to maintain high standing crop without any risk. The study also revealed that, in biofloc systems, the protein content in pelletized feed can be reduced substantially without compromising growth and survival.

Conclusion

It has been argued that advancement of aquaculture will come from the research and development in modern biotechnology, for example, proteomics, genomics, DNA vaccine and transgenic (Troel 2009). While, the ecosystem approach to aquaculture is mainly focused on low input, simple technology suited to the local conditions, providing a sustainable, economically viable and socially acceptable model. However most advancement of brackishwater aquaculture showcasing the economic earnings, in terms of export earnings is mainly due to the "industrial" aquaculture, identified as the shrimp farming model in India, using SPF seeds, formulated extruded feeds, aeration and with the use of various pond management inputs. What required is a balanced growth of these different trajectories, on complementary and integrated mode. There are attempts from private sector to integrate shrimp aquaculture with seaweeds to make the intensive aquaculture more environmental non degradable. Pacific Reef Fisheries, Pvt Ltd. started growing sea weed, Ulva spp in the 5 ha race way of their 98 ha *P. monodon* farm, and reported that this would be sufficient to remove the N and P from the effluent water from the shrimp farm. Further, the secondary crop provides additional income (Shrimp News, 2013).

As India has vast resources of traditional farms which are close to nature, attributing sustainable shrimp farming models with modification wherever necessary will be more defining in its environmental, economic, health and animal welfare goals. However, it is not yet matured to discuss the productivity, economic and ecological performance of these emerging eco-based farming models. Using EABA, Brackishwater aquaculture institutions and industries could initiate and develop an ecologically integrated aquafarming system, that of a community-based, sustainable, and economically viable, along the side of industrial farming sector.

Figure 8. Periphyton over whole bamboo surface.

Fig: 9. Shrimps produced with organic principles at the Kakdwip Research centre of CIBA

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