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Greening the Asian Cage Aquaculture Construct

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World aquaculture production (2013) was to the tune of 97 million metric tons worth USD 157 million, contributing to 43% of total world fish production. That Asia contributes to over 90% of aquaculture fish production of the world undoubtedly establishes the primacy of the fish farmers of Asia in addressing the food and nutritional security of fish mongers of planet Earth. The dominance of the Asian region is anchored upon the congenial climatic conditions and ecosystem diversity of the water bodies, availability of numerous andidate species, warm temperatures resulting in faster growth, high productivity of waters, entrepreneurship of fish farmers, reduced cost of inputs including labour and the ever increasing demand for fish.

Nevertheless, aquaculture in the Asian region does not present a rosy picture to those looking at it from outside the bandwagon. During the past few decades, emergence of cage aquaculture as a promising activity across many parts of the world has resulted in added interest in the diversified production system and had yielded interesting results in many countries.

Cage aquaculture fascinated me a decade back after my visits to the mainland China where I had opportunities to visit numerous cage farming sites and interact with local farmers through interpreters and understand the ground realities of the farming practices. After my return to India, with the special funding from the Ministry of Agriculture, I could initiate the first ever open sea cage culture in India with Sea Bass fingerlings in Visakhapatnam with the prime objective of demonstrating the feasibility of open sea cage farming in Indian seas. Before this pioneering work, MPEDA had already started inland pond based cage aquaculture in the south east coast of India. There were also some attempts elsewhere to establish cages in reservoirs to grow carps. Subsequent efforts by MPEDA, CMFRI, CIBA, CIFA, CIFRI, State Departments of Fisheries and others have made progress and currently these efforts are being taken up by several farming communities, some supported by the state fisheries departments, across the country. Thus, it is the most appropriate time to organize the 5th international cage aquaculture symposium in India where the farming communities

are fast adopting the concepts and practices of cage aquaculture. This will give an opportunity to share experiences and understand the developing technologies, trends, issues and constraints across the Asian region.

The hallmark of the Asian region is its diversity which is reflected everywhere. This is explicit in the area of cage aquaculture also by virtue of the species diversity of cultured species, the habitats, the variety of designs in cages, the techniques employed, feed management, harvesting patterns and market practices.

The history of modern cage aquaculture in Asia is rather short. Freshwater cage aquaculture is believed to have originated in the Asian region first in the Mekong basin countries, but has developed into all water bodies and is extremely diverse in nature with varying types of cages in structure and design, species cultured, feeding and management and husbandry practices, and intensity of operations. Stand alone to cluster of cages are seen in freshwater bodies with varying designs and materials. Massive quantities of fish are produced in these regions using cage farming of species such as Pangasid catfishes. In the Indonesia, combinations of common carp and tilapia are farmed in cages. In the seas, cages of hanging type (lantern net cages) are in vogue in many places such as Korea for culturing bivalve molluscs. Such cages are also used in Japan, China, and south Pacific seas for pearl oysters and abalone. Large floating cages are of recent introduction in the Asian region. Many seas, for example the south China sea and Japanese waters, are prone to cyclonic storms and open sea cages are most vulnerable, a fact which limits the spread of cages in many places. The last 45 years have seen the introduction and rapid spread of the Norwegian type of cages in south east Asia and China. Presently, 95% of marine finfish farmed in Asia are from open sea cages, brackish water cages and cages deployed in creeks and inshore waters. There are about 80 species of fish currently farmed in the Asian region, common ones being Asian seabass (*Lates calcarifer*) and the milkfish (*Chanos chanos*), amberjacks (*Seriola* spp.), snappers (*Lutjanus* spp.), groupers (*Epinephalus* spp.) and cobia (*Rachycentron canadum*). In India, currently cage farmed species, the Asian Sea Bass, Cobia, Milk fish, Lobsters and Pompano although in very small quantities only in a few maritime states.

China has extensive open sea cage units. Chinese cage aquaculture started only in 1970. In the early years, it was only on artisanal scale, but by 1980, it expanded to commercial scales. In the late 1970s, Huiyang County and Zhuhai City, Guangdong Province tried to grow marine fishes such as groupers and seabream in cages. Beginning in 1984 other counties and provinces (e.g. Fujian and Zhejiang provinces) also began to grow marine fish in cages. In the 1980s, the number of marine fish cages in the three provinces of Guangdong, Fujian and Zhejiang had exceeded 57,000 and more than 40 species of marine fishes were farmed. Currently, over 1.5 million cages are deployed in the coastal waters of China.

Myanmar has cage aquaculture of several species such as the Groupers *Epinephelus malabaricus, E. bleekeri, E. tuvina* and Sea Bass *Lates calcarifer*. However, all the seed come from wild. Thailand grows 4 species of Groupers *Epinephelus coioides, E. malabaricus, E. fuscoguttatus, Plectropomus maculatus,* 2 species of snappers *Lutjanus argentimaculatus* and *Lutjanus* sp. and the Sea Bass *Lates calcarifer*. Also grown are the Square tailed Mullet *Liza vaigensis*. Malaysian cage farming has species such as *Lates calcarifer, Lutjanus argentimaculatus, L. lemniscentus, L. johnii, L. erythropterus,* Groupers *Epinephelus coioides, E. malabaricus, E. sexfasciatus, E. fuscoguttatus,* Travelly, Pompano, Cobia and Tilapia. In Indonesia, several species such as the milk fish *Chanos chanos,* Sea Bass *Lates calcarifer*, Groupers *Cromileptes altivelis, E. fuscoguttatus, E. polyphekadion, E.*

coioides are extensively farmed.There is a strong hatchery production system for most species in Indonesia, thanks to the oceanic waters and ecosystem providing many suitable species for broodstock. *E. fuscoguttatus, E. coioides, and Cromileptes altivelis* are all hatchery produced. Most of the hatcheries are small and private, with low survival rate; however the high fecundity of the species used make the hatcheries very profitable in operation. Even Vietnam cage aquaculture is extensive, but much of the seed comes from wild sources. Eleven marine species such as *Epinephelus coioides, E. tauvina, E. malabaricus, E. bleekeri, Rachycentron canadum, Lates calcarifer, Psammoperca waigensis, Lutjanus erythropterus, Rhabdosargus sarba, Sciaenops ocellatus* and *Siganus* sp. are grown. Hong Kong has a very vibrant live fish market fuelling widespread interest in cage aquaculture. Species grown include *Epinephelus tauvina, E. chlorostigma, Rachycentron canadum, Lutjanus russelli, L. argentimaculatus,* White blotched Snapper, Head Grunt, Crimson Snapper, Gold lined Sea Bream, Japanese meagre, Pompano, Red Drum, Black Porgy and Yellow fin Sea Bream. In Japan scallops, abalone, oysters and seaweeds are grown in net cages. Finfishes such as Yellow Tail, Blue fin Tuna *Thunnus thynnus*, Barfin flounder *Verasper moseri, Epinephelus* spp are the main species in cage farms. Taiwan province of China has over 2000 hatcheries operating in a value chain fashion, some developing broodstock, others breeding fish, yet others developing the nursery stages while several others focussing on the grow-out. The main species are *Epinephelus coioides, E. lanceolatus. Trachinotus blochii, Lutjanus argentimaculatus. L. stellatus, Acanthopagrus latus* and Cobia. Korean cage farms focus on *Pleurogrammus azonus, B*astard Halibut *Paralichthys olivaceus, Mugil cephalus, Epinephelus septemfasciatus, Seriola quinqueradiata, Lateolabrax japonicas, Chrysophrys auratus, Stephanolepis cirrhifer,* fishes of family Scorpaenidae and Korean Rockfish *Sebastes schlegelli.* Extensive culture of bivalves from lantern net cages from long lines is hallmark of south Korea. In the Philippines, milk fish is an important component of the aquaculture system. The bulk of the production is from freshwater and brackishwater grow-outs, the marine cages contribute to about 12 to 15% on the total production. Much of the produce is locally used, as the areas are wide apart, market dynamics are difficult and lack of coordinated efforts for marketing, technology transfer and back stopping and poor export linkages.

Australia, New Zealand and the Oceania started cage farming as early as the 1980s. The Atlantic Salmon *Salmo salar* culture was initiated in Tasmania, followed by the Chinook Salmon *Onchorhynchus tschawytscha, Southern* Blue fin Tuna Thunnus *maccoyii*, the Sea Bass (Barramundi) *Lates calcarife,* the Yellowtail Kingfish *Seriola lalandi,* Tilapia and carps which are the dominant species. The countries in the Oceania such as North Marianas, Marshall Islands, Micronesia, Palau, Hawaii, French Polynesia, Solomon islands, Nauru, Papua New Guinea, Pitcairn, Niue, Tonga, Samoa, Cook islands, Tokelau, Fiji, Kiribati, Tuvalu, Wallis islands, and Vanuatu have cage grow-out systems for several species including Tuna, Barramundi and Salmon. Much of these are grow-out systems owned by private players with industrial interests. Australia and New Zealand have strict regulatory measures for cage farming as well as for collection of wild seed.

In my talk today, I wish to focus attendtion to issues on sustainability and inclusiveness of Asian cage aquaculture scenario, without further going into the review of Asian cage aquaculture. Asia is the largest multispecies cage aquaculture production hub with over 80 marine species and about 20 freshwater species being farmed. So it is a massive activity across the Asian region. However, I am of the view that cage aquaculture by being strongly intensive can not support the objectives “supplementing capture

fisheries, poverty alleviation, livelihood, rural food and nutritional security, feeding the millions, *etc*". This hype is only populist jargon and we all have heard enough of these. In my opinion, these are not the drivers of cage aquaculture. The real objective and outcome of cage aquaculture, which none is willing to openly admit, is "business" which means entrepreneurship, profitability. I am of the considered opinion that cage aquaculture in developing Asian countries is only a business opportunity to whomsoever it may concern, they be farmers, fishermen, entrepreneurs or industry. Of course, there are secondary business development, employment generation, improved living standards, additional income, allied industries, all contributing to the welfare of the people in this and related activities. These are only fall outs. The unregulated spread of the new initiatives across the Asian region is bound to boomerang just as the shrimp aquaculture did in the past.

There are well structured regulatory systems and guidelines for cage aquaculture in some of the Asian countries. Guidelines and regulations in Norway, U.K. Faroe islands, USA. Japan, Australia, New Zealand are good examples. However, in the Asian countries either the regulations are weak, un-implementable or absent. In such a situation, it is imperative for those concerned to look beyond production and design frameworks to make the Asian cage aquaculture responsible, sustainable and inclusive.

Therefore, I have questions to ask. Currently there are about 80 or more marine species and about 20 freshwater species grown in cages in the Asian region. As a strategic region providing 90% of farm grown fish to the world, there is urgent need for regional planning, monitoring and greening agenda. Why are we doing cage aquaculture at the cost of fishery resources? Who benefits? Is the technology used viable, resource and environment friendly? Is there an equitable share of profits for all players? Are all our present practices "green"? Are these technologies sustainable, safe? Are they environment friendly? Are they economically viable in the long run? Are they inclusive? Do these practices destroy the resource resilience? Do they affect the biodiversity balance? Do they affect the trophic structure? Are there dangers of introduction / escapes and spread of non-native species? Are there dangers of introduction of native or alien virus, bacteria, parasites, diseases in intensive culture systems? Is it not a priority to address these questions first and take a holistic view, rather than sweeping uncomfortable questions under the carpet and going ahead with limited agenda of the operating agencies? How do we make our current cage aquaculture practices GREEN?

Today we have the cream of Asian cage aquaculture scientists and entrepreneurs here in this hall. As individual countries we have our own agenda and priorities. However, without forgoing these, could there be a meeting point with a common agenda to make the respective cage aquaculture constructs GREEN? How do we address some of the common concerns?

When we are in the driving seat, the vision is the road ahead, the destination. In cage aquaculture the sole objective is to produce more fish. We fail to see the rear view, the impact. We fail to see the side roads, the others who are traveling, the damages caused, and the macro scenario, to look beyond. We feel that what we do is right, if anything is wrong, it is for others to make corrections.

Cage aquaculture originated as an industrial activity in the 1960s with the success demonstrated by the Norwegian initiatives, followed by other European countries. The early success in Norway prompted development of salmon grow-out in cages in Scotland, Ireland, Faroe islands, Canada, North East USA coast, France, Spain, Australia and New Zealand. It aims at producing large quantities of fish by holding

them in controlled cages and through supplementary feeding and grow-out management. In the Asian region, China, Taiwan, Japan, Vietnam, Indonesia, Australia and Oceania are the major players. The objectives and priorities of each country may vary; however, the ultimate objective is entrepreneurship and profitability. Except in experimental stages controlled by government laboratories or departments, all cage aquaculture production is in private hands. When profit is the driving force, many other areas are often neglected.

Who benefits? We have heard enough of the so called drivers of cage aquaculture, such as supplementing capture fisheries, poverty alleviation, employment generation, food and nutritional security, *etc.* which all are nothing but key words for attracting interest or funding support or governmental subsidies. Cage aquaculture is certainly not going to address any of the above directly. The greatest benefit in the form of profits lies in between the farm gate and the consumer's table. Is there other benefits, these are all fall out of cagefarming. Are there equitable share of profits for all players? The answer is no in most countries. This is one reason why many Chinese farmers are signing off. They are no longer able to enjoy the benefits and profits they once enjoyed from open sea cage culture. Still, many of them survive because of the high price for live fish they get from export markets.

Where and how the sites are chosen? There is a tendency to project the cage aquaculture potential in relation to the length of the coastline, presence of creeks, lagoons *etc*. and postulate high growth opportunities for this activity. This is not true in reality. First, the topography and extent of the coast are not the only criteria for locating the cage farms. There are numerous factors to be considered including the depth, currents, water quality, impact to the environment, traditional rights of the users, domestic and industrial effluent discharges, nearness to cities and towns, present and future developmental agenda of the government and industries, water body partitioning master plans, threatened ecosystems, security and ease of operations, boating and shipping channels, nearness to live fish market or processing facilities or markets and a plethora of related factors including public perceptions. Many Asian countries have relatively shallow waters which provide extensive open sea areas. However, the threats of cyclones and heavy storms are factors limiting the operations. Also countries such as Indonesia, the Philippines, other island nations of the Indo-Pacific have extensive coral reef ecosystems which are ideally left free without human interventions. India, has rather deep coastal waters and strong wave action in the western seas, while on the eastern marine reserves, coral seas and shallow waters limit the actual availability of sites suitable for laying cages. There are guidelines and master plans in many of the developed Asian countries which prescribe the norms for establishment of cages and for licensing of the activity. Others in Asia are yet to frame such guidelines and policies. The duty of the researchers and research organizations is to sensitize and advise the respective governments for developing and implementing such policy guidelines so that cage aquaculture development is planned, sustainable, environment friendly, monitored and regulated to safeguard all concerns. Most scientists and governments appear to be unaware of the impacts and adverse effects when they are able to see only increased production as the objective of cage aquaculture. We need to take lessons from the past story of shrimp aquaculture in Asia and present another disaster which can much more serious as it is carried out in the open seas and much greater geographical extend.

Are the grow-out systems Green? There are many types of cages and production systems available

today, starting from the traditional fixed artisanal cages to modern floating cages, semi-submerged cages, fully submerged cages, towing cages, all in varying shapes and sizes. A great deal of engineering skills has gone into the design and erection of advanced cages which are established as part of cage aquaculture industry. These cannot be compared to the types of cages and scales of operations where small farmer groups and entrepreneurs are involved. Industrial cages have more impacts if they are concentrated in same area, such impacts are complex and massive. Even large numbers of small floating cages also can result in many adverse impacts. The adverse impacts on the environment are rather well known, but poorly addressed. The dangers of cage aquaculture in sensitive and threatened ecosystems such as coral reef habitats, mountain streams, island ecosystems, marine reserves are also not well addressed. Damage to the local biodiversity is another aspect to be understood and addressed. This can happen starting from the very process of establishing the cage farms to dangers of escapes of undesirable species, introduction of predators, introduction of parasites, virus and diseases, collection of wild seed and genetic pollution from escapes.

What is the source of broodstock? Developing and maintaining healthy broodstock is an essential prerequisite for a well-managed cage aquaculture system to ensure steady supply of adequate quantities of fingerlings to farmers. Certain species of groupers (mostly genera *Epinephelus* and *Mycteroperca*) are monandric protogynous hermaphrodites, *i.e.* they mature only as females and have the ability to change sex after sexual maturity. Some species of groupers grow about a kilogram per year and are generally adolescent until they reach three kilograms, when they become female. However, some other groupers are gonochoristic. Gonochorism, or a reproductive strategy with two distinct sexes, has evolved independently in groupers. Captive breeding of such fishes may pose problems and long term efforts may be needed for successful hatchery techniques. Also, selective removal of large sized Grouper from the wild population for live fish export market as practiced in the Andaman & Nicobar waters is a threat to the ecological balance and breeding potential of the wild stock which along with intensive collection of grouper seed from wild will have long term adverse impacts on the resources.

Are the seed sources Green? Ideally the source of seed for the cage aquaculture must come from hatcheries as practiced in most countries like China, Taiwan and Australia. However, collection of fish seed from wild is a common practice in many situations where hatchery supply is not there or is inadequate. It is alarming to note that even responsible institutions have been recommending for increasing the efforts for collection of wild seed without realizing the consequences on the biodiversity, species not used for cage aquaculture and the stock health. Basic understanding of the larval biology and ecology is essential before venturing into wild seed collection. Capture based aquaculture is only semi-aquaculture in the true sense, perhaps even comparable to tuna fattening in cages which is not considered as cage aquaculture. It is understandable that some species are difficult to be bred and wild seed is an alternative available. While considering wild seed collection, it must be understood that there are two types of species groups with varying situations for the larvae between hatching and entry in to the fishery (recruitment). In one situation, the hatchlings are abundant and during the course of its early larval life which is a critical period, most of them die due to many factors including food availability and a factor called density dependent mortality. This results in survival of only a few larvae to young adults. In such cases, collecting the wild seed which arein the early stage of development is reasonably justified as otherwise most of them will anyway die in their early life. If collected and nurtured, then these seed can be saved from perishing from natural causes and can be

grown to adults. No harm will be done to the resource resilience in such cases. However, such basic information on larval ecology is not available for most species in the Asian Region. In the other type of species group, in the early larval life, when most of the hatchlings survive between hatching and recruitment and the density dependent mortality is low, removal of the wild seed upsets the natural balance in the foodweb because almost all of them would survive and become adults and play their roles in the foodweb. Selective removal of a segment of the food web is detrimental to other components of the system and therefore must be avoided. These facts must be well understood before publicising the idea for making recommendations for wild seed collection. In countries such as Australia and New Zealand, collection of wild seed is not permitted. But development of hatchery is an expensive R&D affair, and therefore before investing in hatchery, the feasibility of grow-out must be tried and process established. Thus blanket ban on collection of wild seed is not conducive to development of hatchery at least in the early stages of cage farming development. Many responsible institutions suggest capture based aquaculture (CBA) without realizing the rationale and argue that CBA enhances marine fish production and reduce wastage of resources as low value bycatch is used up as feed for production of high value farmed fish. This argument has not many takers. Across the world, use of bycatch for feeding farmed fish is being discouraged and the responsible aquaculturists, we need to prevent this abuse of fishery resource. For long term sustainability, the seed supply should follow the green guidelines so that anthropogenic interferences do not adversely affect the foodweb and the wild stock.

There is a praiseworthy practice followed in countries like Thailand, Indonesia and Taiwan where a portion of the millions of fertilized eggs or hatchlings from a single spawning are supplied to farmers for rearing them in private farmer owned backyard nurseries who later stock them in cages. This is one reason why cage farming has spread extensively in these countries. China also obtains a great deal of seed from imports. This is an excellent model which can be adapted in other countries where many hatcheries cannot be set up for various reasons. Farmers can be trained to rear the larvae in backyard nurseries and feed the larvae with formulated feed right from juvenile stage. This will also help in reducing the use of trash fish in feeding cage farmed fish. Small scale hatcheries in Indonesia shift breeding from one species to another depending on market demand, prices and economics. Establishing such multipurpose small scale hatcheries and/or adapting the remote nursery model along the coast could be an ideal alternative for India for extensive development of cage farming in the country.

Are our present feeding practices Green? Cage aquaculture using trash fish as feed is not a green practice and therefore this practice should stop forthwith. One criticism against aquaculture is that its growth is a direct threat to the wild fish resources. This is because of the use of wild caught fish as feed as well as the use of large quantities of fishmeal from marine biodiversity resources including fish. Biodiversity destruction is the immediate fall out of cage farming. Both direct and indirect impacts are well known. The first step for making cage aquaculture green is by addressing the threats to biodiversity. There are organizations promoting cage aquaculture and predicting tens of thousands of tons of fish production from cage farmed fish fed by low value fresh or frozen fish. One statement from India predicts production of 1,0000000 tons of fish produced through cage mariculture by feeding them with low value trash fish. Under the Indian conditions, 3.3 kg of pelleted feed or 9 kg of trash fish are needed to produce 1 kg of cage farmed fish. If such a projection has to become a reality, then we need 3.3 million tons of formulated feed or 9 million tons of trash fish. When the total marine capture fisheries

production from the country is only 4million tons, how are we going to feed the cage farmed fish with 9 million tons of trash fish? If pelleted feed are used, at moderate estimate of cost of feed at Rs. 35 per kg, we need Rs. 11.55 crores for feed and Rs. 7.7 crores for over heads. So where is the profitability unless farm gate price of fish is over Rs. 500 per kg.? Imagine also the adverse environmental impacts such massive operations cause to the ecosystem. Such unrealistic projections can be misleading for the farming sector and adversely impact the credibility of organizations responsible.

Is the cage culture practice sustainable and resource/environment friendly? Impact of cage farming on environment is a topic which has been extensively dealt with. Wherever there is human interventions with natural systems, adverse impacts are certain. Intensive culture in cages has caused eutrophic situations in many grow-out areas. Outbreaks of red tides are common in the Asian region which can affect the cultured fish and can result in total loss. Therefore, the objective is to minimize such adverse impacts rather than ignoring them. If the practice has to be sustainable, we need to consider all aspects of sustainability. Modern aquaculture practices are largely unsustainable as they consume natural resources at a high rate. Intensive aquaculture cause extreme environmental pollution and result in disease outbreaks. In many countries cage aquaculture uses either low value fish or formulated feed which has a high input of fish proteins and oils. The idea of producing carnivorous fish such as salmon, sea bass, tuna, various perches, eels and other species on a diet rich in fish meal and oil makes commercial sense, as the farmed fish fetch a much higher market price than the fish ground up for fish meal or chopped and thrown into the cages. However, most of such low value fish in the tropics are livelihoods of small enterprise opportunities and cheap food-fish for coastal poor in the Asian countries. This certainly adds pressure on the wild stock and affects natural recruitment in the seas. Therefore the efforts should be to produce fish using efficient and cost-effective methods to improve the life of human beings while judiciously utilizing and conserving available resources and protecting the environment.

Are they economically viable and inclusive? Economic viability is a relative term. What is economically viable in one country may not be viable in another. Taking into consideration the prevailing prices of components, labour, depreciations and market fluctuations, the economic viability will have to be worked out for each culture system, place and species based on actual field results. Economic analyses made by certain institutions are far from real situations and have no consequence. Even the survival rate calculated or the production figures projected are far from reality. Studies have shown that survival in cages in the Asian Region is about 40%. Independent commercial production figures are to be generated by independent agencies to arrive at the actual situations. In the unorganized sector such as small scale fish farming, the producer gets only a marginal profit while the real profit lies between the farm gate and the consumer's table. When the production is massive and the harvest is not staggered and without proper value chains, the price realized will be less than the wild caught fish price. When the supply chain is well established and the market is vibrant, for example the live fish market in Taiwan, Hong Kong, China, Thailand and Singapore, the fish has fancy prices and the whole operation is very remunerative. But this cannot be realized across the Asian countries, unless proximity between the places of grow-out and the consumer market is near so as to allow live fish transport and holding. Economics of Salmon or Tuna farming (= tuna fattening) is quite different as they are part of well-established value chains catering to the needs of affluent discerning consumers. Inclusiveness in cage farming is currently

limited to the labour inputs by the farmers and labourers. Except in the case of traditional cage farming practiced in parts of Lao PDR, Cambodia, Vietnam, modern cage farming is capital intensive and not affordable to Asian fish farmers who do not have the economic backing. Governmental incentives and subsidies to a great extent support much of fish farming activities in countries such as India. The produce from cage aquaculture is targeted at a niche domestic market and can be made profitable with proper market chain. However, making such operations inclusive in the real sense is only wishful thinking. Much of the inclusiveness is restricted to labour wages and other fall outs. If cage culture practices are taking away small pelagics which form the livelihood and or food fish of coastal poor, the practice can never be considered inclusive.

Do these practices destroy the resource resilience? As already discussed, aquaculture *per se* is a resource unfriendly activity, be it pond based or cage cultured. Impact on biodiversity is many sided, from wild seed collection, destruction of biota at farm sites, upsetting the trophic chain, use of wild caught fish for fishmeal, fish oil or as bycatch wet fish food. Since feed cost is the major recurring cost in cage farming accounting to as much as 50% of total costs, and feed cost is decided by the source of protein which is currently fish meal, efforts must be on for finding viable alternatives. Use of fish processing factory waste is a viable option for some limited quantities. Poultry by-product meal, meat and bone meal, feather meal, blood meal, soybean meal, cotton seed meal, Rapeseed meal *etc* have been used as part of protein source in fish feed. Such efforts will reduce the quantities of fishmeal in the diet and reduce not only the cost of the formulated feed, but also reduce the pressure on the wild resources as well as reduce the ever increasing demand for fishmeal. However, the adverse enviornmental impacts of the residual feeds and wastes from cages is yet another aspect not fully realized. Green cage farming has to look into this aspects and design strategies to cope with the environmental damages of this impact. The recent efforts of some organizations to come with substitute to reduce the fish meal content in the feed are praiseworthy. A new sustainable fish feed ingredient that can reduce the aquaculture industry's reliance on fish meal in likely to be launched in 2018 by California based Calysta Inc. The product called FeedKind™ Protein is a non-GMO high quality microbial protein that provides a cost effective alternative to fish meal, approved by the EU for all fish and livestock feeds. Such innovations are the game changers for aquaculture industry and will usher in a sustainable and healthy development of the industry.

Are there dangers of introduction / escapes and spread of non-native species? Many countries have strict rules regulating or preventing introduction of alien species for aquaculture. In spite of such bans, many Asian countries have several alien species introduced and such introductions are continuing. When such species are introduced, there will be continuous threat of them escaping to local ecosystem and upsetting the balance, predating upon native species and often introducing parasites, bacteria and virus. The likelihood of genetic pollution of native stock is very serious and there is need for research and analysis and impact evaluations.

Are there dangers of introduction of native or alien virus, bacteria, parasites, diseases in intensive culture systems? A classic example of dangers of introduction of alien virus to the ecosystem is the mass mortality of native Pilchards in the Australian waters from the suspected virus introduced from imported frozen wet fish used as feed for cage farmed Bluefin Tuna. Such dangers do exist in all systems where wet feed made out of low value bycatch is used as feed. Currently in Australia, only formulated feed are used for all cage farmed fish except Tuna, for which a massive research programme is on for developing formulated feed. Use of bycatch for

feeding cage farmed fish has to end, the earlier the better in all parts of the Asian region for several reasons which are now explicit to all. Governmental regulations must be brought into place in the Asian countries for making this happen and scientists and organizations in the region has a major responsibility in ensuring full compliance in their home countries. Conferences such as the present one should not only flag these issues, but also use these opportunities to convey the message to the farming countries in the interest of conservation of the over exploited marine fishery resources as well as for ensuring long term sustainability of cage aquaculture.

Way forward

Establishing guidelines, rules, regulations and safeguards is the first and foremost need of the sector in all the Asian countries where such policy frameworks do not exist. This includes all aspects from site selection, land / water area planning, licensing, lease rights, insurances, traditional rights, common property user rights, wild seed collection, pollution of the environment, genetic pollution and issues related to escapes, introduction of exotic species, quarantine protocols, regulations against use of wild caught fish for stocking, use of bycatch for feeding, development of small hatcheries and nurseries run by farmers, supply chain development, application of polluter pays principles, subsidies for good management practices, preventing use of chemicals and antibiotics, value addition, marketing linkages including cold chains, conservational mariculture, technology back stopping for small farmers, training and awareness programmes. Rather than encouraging vertically integrated large scale industrial cage farms, support for fisher owned small scale resource and environment friendly farms with local fingerlings obtained from local hatcheries or nurseries will make the practice resilient and remunerative to the primary producers. Offshore large farms are not likely to be the answer for cage aquaculture in Asia. Clusters of well managed small farms with farmer participation and technological back stopping from mandated institutions will be the game changer for Asia which will continue to remain the major aquaculture fish producer of the world. Both constraints and opportunities of the Asian scenario will continue to regulate and develop cage aquaculture in the Asian region and the diversity in species, ecosystems, culture practices, culture methods and incentives for growth shall help Asia to contribute significantly to global production of cage farmed fish.

The emerging era is one of safe and responsible food production with traceability and certification controlling the opportunities. Responsible and safe aquaculture will continue to grow and flourish while other systems and practices will gradually fade away. The CAA5 is the fifth in the series of cage aquaculture organized by the Asian Fisheries Society and this is the right opportunity in time for all Asian cage aquaculture nations to come together and resolve to work by sharing experiences and expertise towards ensuring safe and responsible fish production for the world population. Such conferences should not remain as avenues for discourses of science and technology, but also as opportunities to find solutions and work together towards common goals in the sector to attain sustainable growth. Both AFS and NACA have responsible and increased roles to play in this area. While departing after this conference, the single thought to take home in your minds should revolve around the way forward for greening your country's cage aquaculture and what you can do about it. Three years from now when we meet at CAA6, we should be able to hear from you the great strides your country has made in this direction. Till then, good bye and safe, responsible aquaculture.

Thank you.