*Report on the workshop on*

# Research Needs in Sustaining the Aquaculture Sector in Asia-Pacific to Year 2025 and Beyond

***June 4th to 7th, 2007, Rayong, Thailand***

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# Contents

# Part I. Preparatory activities

## Evolving the concept

The idea of evaluating the research needs for sustaining aquaculture in the Asia-Pacific, the region that produces nearly 85 % of global aquaculture, provides direct and indirect employment to millions, concentrated in particular in rural regions, and a primary production sector that contributes significantly to food security has been mooted around at many fora. Although much has been documented on the production and socio-economic aspects of this growth sector1,2, in the past two decades the sector had begun to confront new challenges in a changing global scenario and consequently the need for fresh areas of research to address these challenges have been acknowledged widely. The workshop therefore was convened to evaluate such research needs and also to bring to the forefront, issues that are relevant to sustaining aquaculture in the region, to the notice of relevant planners, managers and policy makers, and potential donors.

In order to achieve the above NACA initiated discussions with the IDRC, and reached agreement on the need to have a workshop that brought together the necessary and wide expertise, including both natural and social scientists. On reaching agreement on the funding workshop arrangements were put on track over a period of nearly 6 to 8 months, and developed in stages and through extensive consultations with prospective participants and the IDRC.

## Workshop objectives

Asian aquaculture has many a success and some failures. There had been many a review on Global Aquaculture and Asian Aquaculture, and in essence all these reviews have dealt with the trends per se, but have not attempted, explicitly, to address the main research issues and needs to sustain Asian aquaculture and specifically to explore how aquaculture research can contribute to poverty reduction into the first quarter of the 21st century. Equally, there had been reviews on the impacts of improvements in aquaculture, but these are also based on single commodity studies/ evaluations.

Asian aquaculture will have to be innovative and also ensure social responsibility if it were to develop further, contribute to poverty alleviation and well being of the poor rural communities. It is in this context that identification of research priorities becomes imperative.

***The primary objective of the workshop was to conduct a review to identify the main research issues and needs to sustain Asian aquaculture into the first quarter of the 21st century.***

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[1] FAO (2006). State of world aquaculture (advance copy), FAO Fisheries Technical Paper 500, 134 pp Millennium document; SOFIA

[2] NACA & FAO (2004). Emerging trends and experiences in Asia-Pacific aquaculture: 2003. 133 pp.

## *Modus operandi*

- More often than not reviews of such a nature are carried out by a single person. In this instance a group of persons with wide range of expertise and experiences in the sector and related disciplines, were brought together to identify and if appropriate to prioritize the main research issues that could impact on poverty reduction and sustaining Asian aquaculture into the first quarter of the 21st century and beyond.

- On determining of the prospective participants a circular was sent to all on the suggested "Concept Papers" that were to be developed, and also invited the latter to bring forward their own ideas that are suitable for deliberations.

- NACA Secretariat, on receiving responses set out to prepare the background concept papers (**See Annex 1**), which were circulated to all prospective participants and feed back obtained, where relevant, and suitably revised and prepared for the workshop. Most of the original literatures cited in the Concept Papers' were made available at the workshop for reference.

- In addition, NACA also invited three reviewers to document the status of aquaculture and the constraints thereof, for three countries (Nepal, Pakistan, Sri Lanka, **Annex II**) that are considered as not major aquaculture countries in Asia-Pacific.

## *Expected workshop outputs*

- Three case country studies and focused analysis of the past successes and failures in aquaculture activities and the reasons thereof, which have contrasting strategies in relation to aquaculture development and also differing significantly in country GDPs.

- A comprehensive review on research needs and strategic investments in R & D, and corresponding policy changes in Asian aquaculture that would lead to its sustainability and contribute significantly to poverty alleviation in the region.

- Identification of potential activities and leads for possible funding for NACA to enable to proceed further.

- A selection of major "Success Stories" in aquaculture in the region, which could be documented in different forms for different audiences to show case to relevant sectors and also to be utilized for bringing about public awareness on aquaculture, and contribute to changing erroneous public perceptions on aquaculture.

# Part II. Discussion summaries

The discussion summaries are presented in relation to each of the "Concept Papers", and it is inevitable that some degree of overlap could occur. Also based on the discussions some elements that were common to most are presented separately. These Discussion summaries entail the basic elements of research needs and other general recommendation in relation aquaculture R & D in the region.

## *Population growth and food fish needs*

1. The workshop noted that though the bulk of Asia-Pacific aquaculture is small scale at current that there is trend for the unit size to increase and more "commercial" scale farming activities to come into being. In such a context it is important to ensure that small scale farmers coexist with large industrial farmers; one possible means of achieving this is for small farmers to organize as groups, intensify production and/or increase efficiency. It is also imperative that developmental trends in aquaculture are considered in the wider context of other sectors, notably agriculture and water use, water shed management and so forth.

2. It was noted that rice farming has remained small scale in most countries of the region e.g. in Vietnam and Thailand, probably because of land use tenure as land parcels are small. A major driver of change is small-scale farmers cannot make a decent living out of agriculture farming alone. As there is a trend within these countries for small-scale rice farming to become unviable, there is also a trend for farmers to diversify their livelihoods by moving, part-time or full-time, into off-farm employment either in agriculture, industry or service industries, and leasing part or all of their land out to other farmers.. Such farmers are intensifying to increase their income from farming but are also specializing in one or two farming enterprises such as aquaculture, horticulture or livestock which may or may not be integrated in areas like the Red River and Mekong Delta for example.

3. The role of small-scale farmers in production as wellas as a livelihood option (and the definition of small-scale is rather ambiguous and less explicit than desired) may need to be re-evaluated to assess changes brought about by consolidation and the emergence of larger farmers. For example, in Thailand 70% of the estimated 25,000 shrimp farmers are small scale producers, so although they dominate in terms of absolute numbers of farms,. it is likely that the 30% of larger farmers may well be accounting for the bulk of production and the farmed area. This kind of analysis is not possible from FAO statistics, which relate primarily to production aggregated at the national level. It may be useful to collect statistics on intensity and other related aspects in addition to production, to enable better planning and related policy initiatives for aquaculture development..

4. It was noted that the rising global cost of energy is likely to have a significant impact on aquaculture production and in food availability in general, and will create a need to improve efficiencies.

5. Growth of the aquaculture sector must be taken in the more holistic context of land use patterns, pollution, changes in energy consumption and food production patterns.

6. It was noted that the population growth and predictions of food fish needs had been completed for several (four) Asia-Pacific countries. It was indicated that studies for the

other Asian-Pacific countries would provide a better analysis of the level of demand and product types.

## *Alien species and biodiversity in aquaculture*

7. It was pointed out that a number of alien species used in aquaculture have established themselves successfully within the region, over a period of four to five decades, without apparent negative environmental and or biodiversity impacts, contributing significantly to food fish production with equally significant societal impacts. In essence such species have become a part and parcel of the local ecosystems. It was agreed that it is best to consider such species not as alien species but as "naturalized species". Obviously this is a controversial issue and needs further consideration. However, if one were to extrapolate from the agriculture sector and or cash crops and or terrestrial animal husbandry sector no longer are most of the alien species considered as alien any longer; these have become a part and parcel of the existing ecosystems.

8. On the other hand, a term like 'introduced endemic' or 'established exotic' which is often used to refer to species that are now part of the present landscape and therefore no longer seen as alien may be more suitable. All in all this is an issue that needs to be addressed .

9. The group also noted that there should be continuous monitoring of the impacts of such "naturalized species" in time and space.

10. The views on the extent of adverse impacts of aquatic alien species in China remain diverse and controversial. In general in China the adverse impacts of alien species from hatchery-produced stocks that have been translocated and released into the environment, such as large lakes, reservoirs and river systems, leading to mixing and homogenization of stocks, and impacting on the genetic diversity is relatively well documented. Overall, there is need to evaluate the impacts of alien aquatic species.

11. In the region there have been very few studies on the impacts of alien species or hatchery reared seed on biodiversity and genetic diversity of wild populations; for example impacts such as introgression or dilution of wild gene pools due to intermingling with hatchery reared stocks in the Asia-Pacific brought about by cultured, hatchery reared stocks is little known and needs to be studied in detail.

12. There had been substantial and demonstrable benefits from alien species in terms of social and economic gains and societal impacts, some species groups contributing a major share to aquaculture production in the region. However, such instances have been documented only in a few instances, particularly taking into account the societal, environmental and biodiversity impacts (example see[3], [4]). There is a need to arrive at

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[3] De Silva, S.S., Subasinghe, R.P., Bartley, D.M., Lowther, A. **2004**. Tilapias as alien aquatics in Asia and the Pacific: a review. ***FAO Fisheries Technical Paper*** 453, 65 pp

[4] De Silva, S.S., Nguyen, T.T.T., Abery, N.W., Amarasinghe, U.S., **2006.** An evaluation of the role and impacts of alien finfish in inland Asian aquaculture. ***Aquaculture Research*** 37: 1-17

some norms as to the acceptable levels of biodiversity impacts versus the societal gains from production, providing employment etc.

13. The contribution of ornamental fish to alien species / biodiversity impacts is not well studied and is an emerging issue.

## *Climate changes and aquaculture research*

14. The workshop was of the view that climate change and sea level rise will have major impacts on aquaculture and related livelihoods in the Asia-Pacific region, and acknowledged the relative lack of research and preparation in this regard in the Asia-Pacific region.

15. There are many predicted changes associated with climate change and although the range of impact varies, there direction of impact is consistent and therefore these impacts have a high probability of occurring These impacts are likely to bring about major impacts on many aspects of the aquaculture sector as well as the fishery sector. Impacts on the wild fishery sector is important as it is an important for providing feed sources for aquaculture…

16. The major influences on aquaculture could be categorized under the following headings, some of which require research inputs:

    a. Changes in the reproductive patterns of wild stocks, therefore aquaculture broodstock supplies (for replenishment purposes; emerging species)

    b. Changes in temperature regimes in inland waters in particular, that could influence the type of culture activities

    c. Increasing areas of salt water intrusion, particularly in estuarine areas/ river mouths, resulting loss of terrestrial farming land and paving the way of alternative livelihoods through brackishwater aquaculture

    d. Use of GIS as a useful tool for assessing impact on vulnerable areas, such as low lying lands and notably the delta areas of some of the major river systems.

17. Mechanisms for adaptation may be a researchable issue, but there is probably a lot of information available from other sectors and a conscious effort should be made to avoid duplication. The focus should be on the ‘human’ aspects of adaptation as well as the technical aspects.

18. Overall, research into climate change should also consider preparedness rather than just analysis of potential impacts, ie. How can we plan for and cope with change? NACA’s role in climate change may be to help members prepare and adapt to climate change, and to create links with researchers working on climate change, where the work is relevant to the aquaculture sector.

## *Aquaculture and human health hazards – emerging issues*

19. In the context of avian influenza it is questionable if good aquaculture practices could include the use of fresh poultry manure in fish ponds for example in integrated systems.

20. The poultry industry itself is driving changes to guard against outbreaks of bird flu – some suppliers of day old broiler chicks currently in Thailand do not supply fish farms and will only supply those farms that have implemented bio-security arrangements. This has been introduced to protect access to export markets.

21. The group noted that concern with avian influenza has diverted attention from other issues such as conventional food safety hazards and the use of imported livestock / slaughterhouse waste from other regions that, for example, be affected with bovine spongiform encephalopathy.

22. It is regrettable that in many cases farmers continue to use banned chemicals, in part because of unavailability of suitable alternatives (cost, access and efficacy wise), and on occasions lack of alternative 'approved' and effective chemo-therapeutants.

23. There is an increasing focus on food quality and safety within the Asian region, both in relation to local consumption as well as exports, as consumer awareness and affluence increases. Upgrading the capacity of small scale farmers to adopt BMP and GAP to increase efficiency of production systems and produce safe and quality products is of utmost importance

## *Integrated fish farming*

24. While integrated aquaculture is still widely practiced in many countries in Asia, particularly as rural livelihood, changes are occurring in integrated farming systems with some practices falling out of favor while others are being preferred. For example, in China the availability of pelleted feeds and intensification of production has lead to a decline in the use of integrated farming systems involving animal manure inputs, as additional nutrient loading is undesirable. However, there some examples such as cropping of pond dykes which still continue with use of pond silt as fertilizer.

25. There are no firm and or reliable statistics on trends in integrated aquaculture production but the overall trend is probably for a slight decrease, both in China and elsewhere.

26. There are economic consequences of integration systems. For example keeping fields flooded may incur a cost or opportunity cost. In Africa integrated systems may emphasize agriculture rather than aquaculture *per se*, with ponds providing a source of irrigation water.

27. Integrated farming systems should be considered at the landscape level, rather than the individual crop level. Temporal integration aspects should also be considered, as well as the opportunity for mixing intensive and semi-intensive practices.

28. The opportunity cost of labor may be a factor that could decrease the competitiveness of integrated aquaculture systems in future, due to the overhead of dealing with wastes, effluents, feeds for multiple components of the system.

29. Rice –fish integration needs to be looked at fresh in view of the increasing demands on water and the fact that most countries are now imposing a water tax.

30. Biogas has been widely promoted as a byproduct of integrated systems in the past but it is labor intensive to produce and tends to fall out of favor when electricity becomes available. However, it is still being promoted as an alternative fuel in some remote rural areas in China.

31. Australian farms engaged in industrial monoculture of crops are now looking at alternatives to allow water reuse and recycling of nutrients, to offset costs and in response to decreased water resource availability.

32. Environmental economic issues are expected to become more important. The 'polluter pays' approach to greenhouse emissions, nutrients and other forms of pollution may change cost structures and profitability of different practices. This may make certain kinds of integrated farming practices more profitable and attractive to producers.

## *Broodstock and genetic resources management in aquaculture*

33. There is little available in terms of information systems on aquatic genetic resources, as other aspects such as ecology are commonly prioritized over collection of genetic information, and this is reflected in public databases such as Fishbase.

34. There are also few mechanisms for networking and sharing of experience on aquatic genetic resources. The WorldFish Centre has begun reactivating the International Network for Genetics in Aquaculture (INGA) in Aquaculture. It was agreed that NACA should seek to cooperate with INGA and encourage collaboration of its members with the network. On the other hand, if the WFC for one reason or the other does not revive INGA, NACA should initiate action of facilitating the formation of a suitable forum for its member governments to share genetic information and build capacity in this much needed area of specialization.

35. The group noted that the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) has come to include aquatic genetic resources in its mandate for the first time, and was welcomed by the group as a much needed initiative.

36. Breeders associations play an important role in the broodstock management of the livestock sector. It was considered useful to initiate the formation of such associations in the Asia-Pacific for the aquaculture sector, and this could be a role that INGA (or its equivalent in the region) could initiate.

37. There is a need to track international movements of seedstock and its potential impacts on the gene pool, and this would facilitate a more rational regional and or global approach to genetic resources management.

## *Feed development needs*

38. The group agreed that feed development was pivotal to growth and sustainability of the sector. In the Asia-Pacific there is a significant dependence on trash fish/ low value fish as a direct and or an indirect feed source, particularly in respect of mariculture, and the need to wean farmers of using trash fish as a primary feed source. to use pellet feed was considered a priority. The current dependence on trash fish/ low value fish in mariculture in the region is primarily attributed to:

    a. Unavailability of good quality pellet feeds at a reasonable cost

    b. Farmers often have a perception that trash fish/ low value fish is more effective and the stock performs better.

    c. Weaning fish to pelleted feed can be difficult with respect to wild-caught seed. There is a need for to develop techniques for hatchery-bred seed of such species, for both already cultured and new indigenous species.

39. Currently in most parts of Asia trash fish/ low value fish prices are lower than formulated feeds although the former have a much higher moisture content than the latter, and as such farmers need to be provided with incentives to make a switch; in this regard demonstration units to show the efficacy of use of formulated feeds over trash fish/ low value fish from an overall economic and environmental view points, with concurrent farmer education may be necessary. Further more the conversion ratios obtained by even adjacent farming systems, using same feed sources, can differ widely. It will be useful to provide appropriate training courses on feed management.

40. The Cambodian government has banned the culture of snakehead due to the conflict with inland fisheries sector, both in terms of impact on availability of wild seed and use of fish (suitable for human consumption) as the main feed source.

41. In Thailand which also uses wild seed stock and trash fish based feeds for snakehead culture has begun to move away , gradually from these practices, through weaning the wild caught seed to pellet feeds at an early stage, by 5 to 6 cm size the fingerlings are completely weaned.

42. There is an increasing trend, particularly in respect of catfish culture in Vietnam and Thailand, though the species cultured are different, to reduce the dependence of trash fish/ low value fish usage in the moist diets that are often farm-made.

    a. In Vietnam the trend is towards a move to use pellet feeds.

    b. In Thailand hybrid clarias catfish farming rarely uses trash fish/ low value fish but instead poultry industry and cafeteria wastes are used as the main protein source with apparent no loss in performance but resulting in increased cost savings on feeds. However, there has been a considerable recent rise in catfish production also on formulated pelleted feed due to insufficient supplies of by-products as feed.

43. Retailers may soon demand aquaculture products that have not been fed trash fish/ low value fish. This is a potential future ‘ethical trading’ issue, and the region needs to be

pro-active in this regard and make all efforts to encourage farmers to wean from the use of trash fish/ low value fish as the main feed source.

44. Although the advances made in salmon feed development through regional research efforts that has enabled significant reductions in the fish meal usage and improved food conversion ratios and most of all a significant reductions in effluent nitrogen and phosphorous are commendable such a model may not be directly applicable to Asia-Pacific aquaculture in view the great diversity of the species used.

45. While there has been a substantial amount of research into the replacement into fishmeal in formulated feeds, very little has been translated into practice, with the notable exception of the salmon industry. Accordingly, it was considered most appropriate for organizations such as NACA to facilitate the adoption of the available research findings in consultation with feed manufacturers.

46. Some analyses suggest that that by 2010 there will be less fishmeal used in the region than today, if present trends continue. Although the level of fishmeal in diets in declining, the amount of manufactured diets is increasing at a rate to offset diet alterations. Better quality feeds with less fish meal inclusion, better feed management and storage, better performing fish (through genetic improvement) are needed.

47. Development of certification standards may influence future use of feed ingredients, in terms of whether a product may be certified as coming from sustainable aquaculture Based on certified feed (ingredient usage) . It may be useful to encourage dialogues or consensus building on this issue, and the sourcing / traceability of ingredients from sustainable sources etc.

48. Development of standards and standardization of pelleted feeds in the region is highly desirable and indeed is a necessity.

## *Effective utilization of inland water resources for food fish production*

49. It was suggested that the information presented on the average per capita of water is somewhat skewed by China and India, and that a more detailed sub-regional analysis on water availability would be desirable, including also in-country differences.

50. The group noted that ownership of land and water resources is not always straightforward, and tend to vary from country to country. For example, in Bangladesh and Cambodia privately owned land becomes a public/common resource during the flood season, where as in Myanmar there are lease fisheries in floodplain areas where individuals may stock and harvest fish from the lease.

51. Most inland fishery activities and strategies for development revolve around community-based approaches and research in these aspects need to be ongoing and the results disseminated across nations as there is lot of potential inter-nation adaptability of the findings. All in all, the absence of marketing facilities is often a constraint in inland fisheries development, and warrants research in development of markets. In this regard perhaps lessons could be learnt from the rather recent developments of export markets

for carp species, in particular rohu, in Myanmar, which in 2006-07 accounted for 70 million US$ in export value.

52. Stock enhancement of inland water bodies more often than not is conducted in an unplanned and not on a scientific basis. The limited data available indicate that such activities in respect of one or two species have resulted in dilution of the gene pool of the wild counterparts. Apart from the need to conduct a review of successes and failures in stock enhancements aspects of inland fisheries in the region there is a need to conduct more comprehensive genetic studies to evaluate the impacts on diversity of the genetic stocks.

53. Planning tools are needed to guide establishment of reservoir fisheries, both in terms of technical construction and development of support infrastructure such as hatcheries, landing sites and marketing facilities. Equally, sharing of benefits and social aspects of effective use of inland water resources is a major issue. Poor planning in this respect can undermine efforts to improve the productivity of the resource. Communities often do not have any power to influence watershed management; this can lead to losses for example paper mill effluent release killing caged fish in Thailand.

54. Collation of inland fishery statistics is difficult, and there is a need to develop procedures to improve the current situation, on a regional basis, as lack of reliable statistics have hampered development of suitable strategies for optimal utilization of the water resources for food fish production. In this regard the group noted that the forthcoming regional project funded by the Icelandic International Development Agency (ICEIDA) and to be coordinated by NACA is most welcome.

55. Inland waters are increasingly being subjected to pollution, resulting from anthropogenic activities in the waters itself or in the associated watersheds. Such affects are thought not only to impact aquaculture activities directly with loss of stock on occasions, and most of all on biodiversity, and as such both issues need to be addressed urgently.

56. A study of the successes and or failures of different approaches to utilization of different types of water bodies by different groups of resource users, ie. how water bodies are being managed, the issues that are constraining development and how they can be improved, both in terms of productivity and equity/benefit sharing requires addressing.

    a. A high-level review paper could be used to prepare policy guidelines promoting the development of effective local level planning and management systems.

## *Gene technology in aquaculture/use of transgenics in aquaculture*

57. Commercialization of transgenic fish lines poses the risk of transfer of transgenes to natural stocks, with no ability to control or recall dissemination, and it is difficult to predict the ecological outcome(s). China is therefore emphasizing the use of conventional genetic improvement methods, although there has been considerable research into the development of transgenic fish lines (in fact the first transgenic fish was produced in the Hydrobiological Institute, Academia Sinica, Wuhan, China).

58. There is some debate as to whether the culture of auto-transgenic fish lines (ie. that contain additional copies of useful genes from their own genome) is more acceptable than conventional transgenesis. It was noted that consumer resistance to transgenic products is high due to negative perceptions, although the use of transgenic food plants and products containing them are quite widespread.

59. Advances in the productivity in Chinese aquaculture have revolved around the development of improved management practices and intensification. However, the potential vast benefits of genetic improvement have not yet been realized, and these been currently restricted to salmonid species and tilapias but only limited in respect of the vast majority of species cultured in Asia-Pacific region. There is considerable potential to derive additional benefits using conventional selection techniques without resorting to transgenic approaches.

60. There have been some forecasts that the existing rate of increase in aquaculture production will not be sufficient to meet rising demand from population increase without development of faster growing fish strains. It has been suggested that this will lead to greater acceptance and commercial production of transgenic fish lines in Asia and other regions in the medium term, as necessity overtakes consumer resistance. However, it is also likely that demand for fast growing fish lines could be met through conventional non-transgenic improvement techniques.

61. In general, and as opposed to agricultural crops and livestock there has been only limited application of gene technologies in aquatic health management and in breeding programs, and these aspects have to be encouraged in order to ensure that aquaculture is able to meet the expected demands for food fish supplies in the ensuing years.

62. Overall, there is need to initiate planning for the development of an appropriate policy environment in advance with regard to the use of transgenic fish lines, and to keep the community consulted and informed thereof on a regular basis.

## *Socio-economic and policy research themes*

63. Three priority socio-economic considerations are:

    a. Economics of alternative land use patterns: A broad understanding of the economics of land use and social effects is required. Aquaculture must be considered within this wider context.

    b. Ecological economics, including social costs: will become increasingly important as aquaculture intensification increases.

    c. Linkages between production, marketing and trade: How to design products that match consumer preference, and to encourage consumer recognition and acceptance of new or different products. It is necessary to understand

        i. who consumers are and what are their preferences,

        ii. value and supply chain structures, and

iii. marketing strategies and iv) the capabilities of producers.

64. There is a need to address both macro- and micro-economic aspects of aquaculture. It would be useful to analyze the economic viability of different kinds of aquaculture practices and their comparative advantages to allow comparisons to be made with other food-producing sectors, and assess other factors that affect viability.

65. Socio-economics is an often overlooked area of aquaculture research and organizations such as NACA should emphasize the importance of socio-economic issues to their members, as this capacity is lacking in most fisheries and aquaculture institutions in the region. Socio-economic considerations should be integrated into aquaculture research frameworks, not conducted in isolation (while recognizing the need for specialist studies).

66. It would be useful to conduct studies into changes in consumer preferences and projected long-term trends and a holistic approach be adopted towards market analysis or else erroneous conclusions may be made to the detriment of producers. Integrated approaches should be pursued in investigation of marketing and trade issues with connectivity across disciplines. It is important to link technical, socio-economic and marketing aspects.

67. Producer capability should be considered – small scale farmers may not be able to directly participate in some market chains and domestic markets should not be overlooked and may offer producers a buffer against fluctuations in international/export markets.

68. There is increasing interest among major retailers in addressing ‘fair trade’ issues including worker and producer welfare and sharing of benefits, and in future an increasing number of ‘fair trade’ labels are likely. It is important that the needs of all workers should be given due consideration, not just those involved in production for export markets.

69. The notion of aquaculture as cheap food for local nutrition versus luxury protein for export is a simplification. There is a substantial and increasing international trade in so-called ‘low value’ species such as carps, tilapia and catfish, and these issues need to be brought to the forefront and the relevant research work needs to be initiated. It should however, be also noted that there is a trend to value adding to some of the so called low value species catering to export markets and this trend should be encouraged.

70. Increasing market demands are being placed on producers in terms of traceability, food safety, environmental responsibility etc. and the capability of producers to respond to such demands, particularly small-scale, warrants further research.

## *Polyculture vs Monoculture [traditional vs modern?] –a recent change in aquaculture systems in China*

71. Aquaculture in China started with monoculture of common carp. It gradually expanded into polyculture practices as additional species were used in culture systems. Polyculture

of freshwater fish species is often integrated with other agricultural activities. As different species occupied different niches in the pond environment, resource use efficiency could be maximized. The system can yield 12-15 tons per hectare with some simple management measures.

72. Distribution of land parcel size of farmers in China varies by location, from 0.2 to 1 ha. However, farmers may rent land from others to obtain larger area. The area under rice-fish culture in China increased substantially over the past 5-6 years but now overall it is stable, although in some areas it is in decline.

73. While polyculture is the dominant production system there is an increasing trend towards monoculture. This is being driven by:

    a. Introduction of new aquaculture species that is well-suited to monoculture, for example giant freshwater prawn, white leg prawn and catfish.

    b. Pursuit of farmers for high unit production. Monoculture of some species such as common carp can reach higher yields if grown in intensive monoculture (e.g. 30-40 tons/ha).

    c. Other economic considerations such as increasing labour cost.

    d. Changes in production techniques, notably the use of artificial feeds and the opportunity to use species specific feeds.

74. Monoculture breaks the direct on-farm integration of fish culture with other agricultural activities It also increases the exposure of farmers to market risk and price fluctuations, against which polyculture provides a degree of buffering. However, it needs to be noted that monoculture of catfish and tilapias are still integrated with the poultry industry in some regions.

75. High nutrient loading due to intensification can lead to increased adverse environmental impact.

## *Improving lobster aquaculture, marine fish and farming systems and hatcheries in mariculture as a potential research area*

76. Lobster culture, a growing sector, in Indonesia and Vietnam, is based on wild caught seed. Attempts to close the life cycle have not proven viable as the larval period is exceptionally long and mortality (between the pre-settlement and stocking) is very high. Grow-out is dependent on trash fish/ low value fish as lobster eat slowly and pelleted feeds are not suitable.

77. Although lobster are high in the food chain their premium price makes them a highly attractive option in terms of providing income (and thereby, food security) to farmers.

78. Development of seed and feed technologies for mariculture need to go hand in hand. Grouper aquaculture production systems have been successfully adapted to other finfish

species with relatively minor modifications. However, grouper hatchery technology has not been widely transferred throughout the region at this stage, especially into more remote areas.

79. There are some positive effects of grouper aquaculture on biodiversity, in that the live finfish/restaurant trade is increasingly depend on hatchery-produced fish, thereby reducing the prevalence of destructive fishing practices that are often used to capture wild reef fish.

80. There is a trend away from small backyard shrimp hatcheries towards larger scale businesses that are more competitive in terms of economies of scale, quality of seed and capacity to screen for disease. Similar trends are occurring in backyard hatcheries for marine finfish. This is likely a natural developmental trend that will continue. It was noted that small scale hatcheries, though they may be in decline, have generally been useful and successful in supporting the establishment of shrimp and marine finfish aquaculture industries. Also there have been shifts in using hatcheries for different commodities; with the decline in shrimp prices and hence the demand for PL, some of the big shrimp hatcheries have switched to produce marine fin fish. As such market driven changes need to be kept abreast of and the research needs determined accordingly.

81. The Consortium Program (that included NACA, FAO, WWF, UNEP, WB) on Shrimp Farming and the Environment has been successful in consolidating research materials into a set of better management principles and in facilitating changes in the farming practices of producers. Further work is required to support the capacity of farmers to adopt better management practices and to make linkages between BMP product and markets. It would be useful to conduct research into the development of better management practices for other aquaculture commodities and their adoption by farming communities.

## *GIFT (Genetically Improved Farmed Tilapias) tilapia*

82. The primary aim of the GIFT program, conducted over almost a ten year period, was to develop methodologies for genetic improvement of tropical fish species, using tilapia as test species, in view of its relatively short maturation cycle.

83. Risks associated with the release of genetically improved GIFT tilapia strains were discussed. Some participants considered that risks were low, with probably considerable benefit, in using GIFT tilapia in places where alien populations of tilapia had already become established. However, the use of GIFT in areas where tilapia were endemic e.g. in parts of Africa, posed substantially higher risk.

84. Following the wide distribution of GIFT tilapia and subsequent further work on genetic improvement by other institutions it is likely that there are differences between holdings of GIFT tilapia around the world. Some strains are likely to be better than others but there is no available comparative data.

85. It was noted that GIFT had been a successful story in terms of the development of an improved fish variety, dissemination of the improved ‘product’ to producers and in

building capacity in selective breeding, and that it would make a useful case study for drawing 'lessons learned' on genetic improvement and factors contributing to its success[5]. The widespread dissemination of the strain had also raised concerns over the capacity of many countries in terms of policies and strategies for dissemination and to assess and manage biosafety risks associated with trans-boundary movements.

86. It was recommended that the mechanisms put in place through the activities of the International Network on Genetics in Aquaculture (INGA) for international cooperation in aquaculture genetics should be continued and intensified in part as a mechanism to extend the lessons associated with the GIFT project.

## *Tilapia farming in the Philippines: Challenges and lessons learned in relation to rural development*

87. More than 90 % of tilapia seed used in aquaculture in the Philippines is of improved strains. Tilapia aquaculture has had a major impact on the livelihoods of the poorer sectors of the community. A major finding of the Asian Development Bank (ADB) Special Evaluation Study (SES): "An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction" is that just less than half (43%) of the surveyed small-scale households farming tilapia in ponds in Central Luzon were below the poverty) line; for the purpose of the study, small-scale tilapia farmers were defined as those using ponds of a maximum of 1 ha

88. Government should concentrate on providing technical support to farmers in areas in which there is little private sector support, ie. complement activities of the private sector and maximize the impact of the overall effort.

89. Philippine Government statistics reported annual production of tilapia in cages in Lake Taal, Philippines to be about 20,000 tons; however, a recent ongoing detailed study (un published as yet) has estimated production at over 100,000 tons/anuum and exceeding the carrying capacity of the lake by almost three times, suggesting the system was at risk of collapse.

## *Success stories*

The workshop was of the view that it would be desirable to document selected success stories in aquaculture in the Asia-Pacific region, and the relevant documentation to be prepared to target different audiences; such as for example policy makers, farming communities, and other

[5] Gupta M.V. & Acosta B.O. (2004b) From drawing board to dinning table: the success story of the GIFT project. *NAGA World Fish Center Quarterly* **27,** 4-14.

groups. In this regard the workshop participants selected six main success stories according to individual experiences and the group ranked each of these and arrived at the following eight as those that are best to be documented.

The purpose of success stories are to:

- highlight experiences in aquaculture development leading to positive change
- provide understanding of factors and approaches leading to sustainable aquaculture growth and positive societal change
- show that farmers have incentives for and can act responsibly
- provide a direction for future policy change and collective improvement to ensure sustainability of the sector, and
- to mitigate negative public perceptions of aquaculture.

| **Case study** | **Prospective Author(s)** |
|---|---|
| GIFT: Genetic improvement of tilapia through selective breeding | Gupta/Acosta |
| Shrimp farming BMPs and cluster-based approaches to management of small-scale farms | Phillips/Mohan |
| *Pangasianodon* culture in Vietnam | Phuong/So Nam |
| Recent development of rice-fish integrated farming in China | Weimin |
| Successful development of culture of some introduced species in China tilapia, *Macrobrachium* spp., *P. vannamei*. | De Silva/Edwards |
| Backyard hatcheries | Kongkeo |
| Culture based fisheries development in Bangladesh, Vietnam and Sri Lanka | Nguyen/De Silva/Gupta |
| Coordination of technical development and genetic resource management for aquatic and stock enhancement of indigenous *Tor* spp. | Gooley/De Silva |

## *Research needs*

The research needs as determined by the workshop, after extensive deliberations, are arranged under themes, some of which may be cross-cutting. Every effort is made, however, to avoid duplication, and the themes are not arranged in order of priority, and nor the elements under each theme. These research needs are supplemented with Recommendations that may be not explicitly of a researchable nature but which is strongly connected to most of the identified research issues.

### General aspects

90. There is a need to research with regard to the contribution of aquaculture to human nutrition, particularly of rural communities, poverty alleviation and food security in the region. Although these aspects are often taken for granted and often controversial at times, there is a need to substantiate these aspects through quantification, as far as possible.

91. Asian aquaculture is still predominantly small scale, consisting of family owned and managed units, often clustered together in areas conducive to aquaculture practices. Increasingly small scale farmers are confronted with challenges to comply with international trade standards and other WTO requirements, and to maintain competitiveness whilst doing so. In this regard there is need to research on such compliances, the economic and social costs in adapting and ways and means of adapting to the challenges.

## Farming systems related

92. It is generally considered that Asian aquaculture is primarily small scale; small scale is not easily defined but generally refers to small, family owned and managed units. In respect of some cultured commodities small scale farms co-exist with large "industrial scale" farms. However, the contribution to total production of each of these types is hardly documented, and is a researchable issue particularly in the context of rapidly changing scenarios of production units, and other challenges as well as opportunities that the sector confronts as a result of globalization of trade and increasing urbanisation and affluence of local consumers. The information in respect of the major cultured commodities will enable improved planning and developing appropriate market strategies as well as take appropriate steps to improve the livelihoods of small scale farmers.

93. Consensus is that integrated farming systems are important, and there are major changes taking place in these farming systems, and these changes have to be researched on both from a production, socio-economic, food safety and bio-security view points, and from a "landscape" perspective

94. Prepare analyses of the economic viability of different kinds of aquaculture practices, including important traditional practices such as rice-fish culture, and their comparative advantages, to permit comparisons to be made with other food-producing sectors.

95. Based on the successes of the development of BMP for shrimp, there is an urgent need to research on the development of such BMP for other major cultured species in the region, and in this regard work in conjunction with the farmers, as in the case of shrimp, in order for easy facilitation of the uptake of the findings by the farming communities.

96. There is a research need in major aquaculture countries such as China and India for example to assess the status of polyculture, determine the adverse effects of monoculture in relation to the degree of intensification.

97. Aquaculture in the Asia-Pacific has been able to make great strides in production through intensification of the farming practices in the last decade or more. Needless to say that such intensification in some sectors has had major implication on production and livelihoods, the case in point being shrimp culture. Although fin fish aquaculture which constitutes the backbone of the sector have not experienced adversity on a large scale, the continued intensification, especially in areas of limited water circulation is beginning to be counter-productive, and also impacts on public perceptions of aquaculture as a gross environmental degrader. Also potential conflicts between fishers and fish farmers could occur as a result of excessive eutrophication and possible fish kills. Accordingly, there is need for research in selected water sheds to determine carrying capacities and also to evaluate ways and means of reducing

effluent discharge into the surrounding waters, and provide suitable guidelines for policy makers to implement appropriate management measures.

98. Research into the treatment of effluents through integrated aquaculture/ farming systems, such as through hydroponics, mollusk culture and a landscape approach to integration needs to be initiated, particularly in view of the increasing intensification of aquaculture, and use of the former methods as a means of retaining such intensification but resulting in minimal environmental impacts.

## Genetics and biodiversity related

99. Conduct a review of successes and failures in stock enhancements aspects of inland fisheries in the region and develop a suitable research program to conduct more comprehensive genetic studies to evaluate the impacts on diversity of the genetic stocks arising from stock enhancement in selected countries on selected species. Where relevant also address the problems, if any, of impacts such as introgression or dilution of wild gene pool due to intermingling with hatchery reared stocks of alien species in the Asia-Pacific brought about by cultured, hatchery reared stocks, in particular the major cultured species of common usage in the region.

100. Develop a research program to evaluate the negative impacts on biodiversity arising from pollution and related development activities in the water sheds, and incorporate a program for regular monitoring and assessment of such adverse effects, as well as provide suitable guidelines to planners and developers to minimize such influences.

101. Research programs on social, economic and environmental impacts of the use of gene technologies in aquaculture, and on the regulatory and policy frameworks necessary to support responsible use of gene technologies in aquaculture need to be initiated.

102. It was pointed out that there are many alien species that are established in the region, for over five decades, and which are contributing significantly to aquaculture production and livelihoods, without any apparent negative impacts on the environment; the group was of the view that such species be considered as “naturalized” species. The group also noted that there should be continuous monitoring of the impacts of such “naturalized species” in time and space.

103. In order for aquaculture production in the next two decades to be able to cater to the rising demand for food fish supplies a substantial research effort is needed, as in the case of tilapias, to fully realise the genetic potential of the major cultured species. Admittedly, some of this work is ongoing. However, further research on the production of genetically improved strains through selective breeding on many more selected species has to be initiated as a matter of urgency.

## Climate change related

104. The current knowledge based on modeling predicts that there is likely to be an expansion of brackish water in low-lying areas and that this would significantly impact on land use and agriculture. Based on these models research may be undertaken to evaluate how best the livelihoods can be revived through suitable aquaculture developments in such areas.

## Aquaculture/ human health related research

105. In integrated aquaculture, in particular integration with poultry, as well as other terrestrial livestock has been subjected to much scrutiny with regard to potential connection as possible “reservoir” for spreading avian flu, though unproven, requires research inputs from the sector to ensure the continuance of this sector and the produce could be marketed. In the light ofthe above the following research priorities were identified:

    a. Determine the extent to which poultry are integrated with fish, in what ways and to what extent have the practices been influenced by HPA1 virus?

    b. How have fish prices responded to lower supply and demand of poultry caused by HPA1 outbreaks, as well as other world calamities; and associated switches from red meats to fish

    c. To what extent are poultry by-products used in aquafeeds on-farm as well as in industrially formulated feeds? Is HPA1 virus killed in the process? Are such feeds imported/exported?

106. Development of disease control strategies (e.g. vaccines) to minimize the use of chemicals in aquaculture.

107. Development of BMP and GAP programmes for key aquaculture commodities in Asia to address production and food safety concerns

## Broodstock management

108. In general, in the Asia-Pacific broodstock management of most cultured species is not done on a scientific basis, and the situation is being further exacerbated by trans-boundary movement of potential broodstock, as well as unplanned stocking of natural waters with hatchery produced seed. Research on the status of broodstock management of selected species in as many countries in the region, as well as investigations on the affects of stocking into major water bodies are urgently needed, and suitable broodstock management and stocking strategies developed based on the research.

## Feeds

109. There is a need for further research on farm-made feeds, which has recently gone through a transformation in that these are made in small feed mills catering to cluster of farmers, especially in respect of carp farming in India and Bangladesh. The research needs to focus on the current status of use of farm-made feeds in comparison to traditional use of fertilisers and supplementary feeding of separate ingredients and increasing use of factory-made formulated feeds, as well as quality improvement of farm-made feeds in terms of nutrient utilization efficiency and efficacy, and economic gains in their use in comparison to industrial feeds.

110. Research into effluent quality associated with use of trash fish/ low value fish in conjunction with on farm trials on the efficacy of trash fish/ low value fish versus trash fish/ low value fish incorporated moist feeds versus pellet feeds in mariculture needs to

be undertaken; efficacy of farmer feeding practices/ management; the trials also should address they economic benefits, social impacts such as for example on the trash fish / low value fish providers and so on. It will also be appropriate to combine different R & D programs that are on –going, in isolation, to entail a more regional approach.

111. Increasingly animal industry by-products (e.g. blood meal, bone meal etc.) are being exported to the Asia-Pacific from the EU for example, where the uses of such products are banned, and the region is encouraged to use these products in aquafeeds amongst others. As such there is a need to research and assess the suitability of incorporation of these ingredients, from a technical view point as well as from a consumer and legalistic view point.

## Inland waters/ fisheries/ aquaculture

112. Conduct a desk study on Review on approaches to management and community-based organizations involved in inland fisheries development, and evaluate the successes, failures and lessons learned thereof and make suitable recommendations on policy changes that are required to alleviate the prevailing conditions.

113. Economics of alternative land and water use patterns, starting with desk studies and progressing to field research in specific localities/ systems/ stakeholder groups, ie. a preliminary survey followed by action research involving participatory methodologies.

## Marketing/ consumer needs

114. Research on the assessment of the capabilities of small scale producers to meet increasing market demands for traceability, food safety, environmental responsibility and ethical issues is warranted, and findings leading to ways and means to improve their capabilities to adapt to the changing global scenarios.

115. Conduct case studies on consumer preference issues and trends/ projections, both domestically and internationally, and supply/ value chain structures for key aquaculture commodities, and keep the farming community of potential changes

116. It is known that pandemics and world calamities impact on the demand and price of cultured commodities, mostly of the “live fish/ sea food restaurant trade”, and in turn impact on small scale farmers, and the economic viability of the practices. However, the available research on these aspects are scant and it is therefore suggested that in depth studies be undertaken in this regard, based on which recommendations could be developed to sustain and maintain economic viability of such farming practices under these unforeseen condition.

## Miscellaneous

117. Determine the abundance of lobster seed resources in time and space in the region, and combine such studies.

118. In the Asia-Pacific in the ensuing years there is likely to be off shore cage farming developed. However, in this regard the relevant policies and guidelines are not available to most nations. Accordingly, there is a need for research in this context to be

conducted and apprise the policy makers of the potential developments and the legislative needs thereof.

# *Recommendations*

## General aspects

119. The workshop recommended that it would be appropriate for NACA to collate fisheries /aquaculture development plans of each of the member governments (this has been pursued prior to the workshop but had no success) and do a desk study/ an evaluation how the research needs identified at the workshop compare and compliment of the member country aspirations/ plans, and where relevant pursue further in implementing/ facilitation relevant areas of research.

120. Also there is a general lack of understanding and or evaluations of the extents of adoption of research findings ata grass root level, even such studies are conducted on an individual case bt case basis under donor funded research programs. A collective study to determine such successes and why so may be useful in the long run and could possibly generate some useful guidelines in this regard for future adoptions.

121. Explore mechanisms for changing the behavior of governments / policy makers including a possible high level workshop to bring policy issues to Ministers and DGs of Fisheries Departments, as well as related departments such as for example Departments of Environment.

122. Enhance capacity with a greater emphasis on socio-economic aspects of aquaculture development.

123. There is a need to review the constraints limiting small scale producers' ability to meet international trade requirements and participate in national or international market chains. There is a need for institutionally focused research to understand how the small scale sector could be supported and it is likely that a combination of government and private services would be required.

124. Need to focus research more on delivering outcomes. For example, the Shrimp Farming and the Environment consortium was not simply research, but also involved in the identification of key stakeholders and consensus building on key issues and priorities for change, as well as development of mechanisms to facilitate the transition to more sustainable practices.

125. Prepare a review on the environmental services provided by aquaculture and its potential role in rehabilitating coastal areas. There is potential for various species and combinations of species to contribute to the rehabilitation or mitigation of environmental impacts.

126. It was suggested that NACA should continue to facilitate south-south dialogue on aquaculture development and play a lead role in this regard, as had been initiated already.

## Farming systems (BMPs)

127. Experience working with shrimp farmer groups in India indicates that better management practices can permit chemical-free aquaculture that is demonstrably more profitable, has lower incidence of disease and risk of crop failure while also delivering higher-quality product. To date there has been a very low investment in this regard into alternative approaches when the value of Asian aquaculture is considered. As such it is recommended that studies be undertaken on development of better management practices for key commodities in Asian aquaculture, including investigations into alternatives (e.g. vaccines) to use of chemicals in aquaculture production..

## Biodiversity/ Genetics/ Alien species

128. In view of the fact that evaluation of societal, environmental and biodiversity impacts of major alien species in aquaculture in the region are relatively scanty, and the fact that there is a need to arrive at some norms as to the acceptable levels of biodiversity impacts versus the societal gains from production, providing employment etc., major desk studies be undertaken on these aspects in respect of the important alien species in aquaculture in the Asia-Pacific region.

129. There is a need for the development of user friendly technical guidelines for management of broodstock and aquatic genetic resources. The FAO Code of Conduct or Responsible Fisheries (CCRF) contains general principles but this is a high level document. More detailed technical information is necessary to assist hatchery managers and guide restocking of public waters.

130. NACA should initiate action of facilitating the formation of a suitable forum for its member governments to share genetic information and build capacity in this much needed area of specialization, if the World Fish Center fails to revive the International Genetic Network within a reasonable time period

131. Suggest that INGA or its equivalent explore the possibility of establishing breeders association(s) of aquaculturists associated with hatchery management, and in conjunction with such organizations develop seed certification procedures and protocols to ensure sustainability of aquaculture practices.

132. Limited scientific information is available on how hatchery bred seed of indigenous species has impacted on biodiversity or natural fish stocks. Where information is available there are at times social and political issues that prevent data being reported. It is important to create a policy environment in which researchers can work more comfortably and NACA may be able to facilitate the creation of such a mechanism, as has been the case with the aquatic health management programme.

133. There is a pervasive release of poor quality hatchery-produced seed into public waters as part of well-intentioned restocking programs, for example silver barb, *Macrobrachium*, and others. Major issues include inbreeding and poor genetic management of broodstock in hatcheries, a lack of understanding of the population structure between wild stocks, and translocation of seed. Baseline research on stock structure (see 97) is required to support responsible restocking practices, along with

practical guidelines or better management practices on broodstock management and translocation protocols. NACA's research on broodstock management and restocking of Tor spp. in Malaysia may provide a useful framework.

134. Prepare guidelines for better management of genetic issues relating to responsible restocking and translocation of hatchery-reared seed and the like.

## Climate change related

135. There is a need to work with climate change agencies to establish the most likely and worst case scenaorios for climate change and impacts thereof on aquaculture, and prepare regular policy briefs as the data emerge and provide the information to regional governments on a regular basis. Efforts should be made to esnure that efforts are not duplicated and funds are not spent unnecessarily, and also as means of keeping policy makers and the public informed of the scenarios and actions to be initiated.

136. NACA may consider reviewing existing information on climate change, including GIS models and other information from outside the aquaculture sector, and national efforts of members, and develop some scenarios focusing on Asia and Asian production systems, to be presented as a paper to guide policy at the COFI Sub-committee on Aquaculture.

## Feeds related

137. Organizations such as NACA should endeavor to facilitate the adoption of the available research findings on fish meal replacement, with locally available agricultural by-products, a theme of popular research with potentially applicable findings that are already available for many important cultured species in the region, in consultation with feed manufacturers.

138. With the global trend for the development of certification standards on product quality which may influence future use of feed ingredients, in terms of whether a product may be certified as coming from sustainable aquaculture it may be useful to encourage dialogues or consensus building on this issue, and the sourcing / traceability of ingredients from sustainable sources etc.

139. Undertake effective dissemination of research findings on the efficacy, economic viability, environmental integrity and so forth of research findings on trash fish/ low value fish versus moist feeds based on the latter versus commercial pellet feed usage in mariculture in the region, and conduct suitable farmer training in this regard.

## Effective utilization of inland waters

140. Review of the relevant sections of the Bangkok Declaration on Aquaculture Beyond 2000 to evaluate how well the recommendations have been implemented in respect of utilization of inland waters for food fish production and assess constraints if any in implementation of recommendations.

141. Develop planning tools for best practice in aquaculture zoning in inland and marine areas.

## Market related

142. Improve the availability of market related information services and distribution systems for cultured products, irrespective of the unit value of the species.

## *Overall assessment*

149. There was general consensus that the workshop was a success and that it met the objectives that were expected. The deliberations on each of the concept papers were intensive, and the vast experience and expertise on the subject matter, enabled agreement to be reached on the research needs and general recommendations that could be carried forward.

150. The workshop successfully prepared a wide research agenda for supporting future aquaculture development in the region, as well as a number of avenues for further collaborative research program that might be taken up under NACA. The outcomes will be submitted to the Technical Advisory Committee and the Governing Council of NACA for further prioritization by members.

151. Regarding future cooperation with IDRC, it was noted that there were a number of avenues for collaboration in support to a sector that provides livelihoods to millions of rural poor in the Asia-Pacific, which in turn provides over 45 percent of all sea food consumed globally. Two priority researchable issues that surfaced in this regard were:

- research on Integrated Fish Farming / Human Health and
- Markets and Pandemics and Livelihoods
- Novel technologies and policy issues?

## *Acknowledgements*

NACA wishes to express its sincere thanks to Dr. Brian Davy, formerly of the IDRC for initiating this activity, to Jean Woo for pursuing with the activity and to the IDRC for funding. NACA also wishes to acknowledge the inputs of all the participants for very willingly collaborating at all stages.

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# Part III. Background material used in the deliberations

The "Concept Notes" and a note on a success story from research, presented here represent a few of the major topics that we believe should receive attention but is not considered to be exhaustive, however. Hopefully these provide the base line for discussions and the format of the presentations that are expected from the participants. There will also likely to be some overlap in the contents, which perhaps is unavoidable to a certain extent.

The literature cited in the notes is available for reference, if needed, and all other presentations are also expected to be backed up with relevant citations. Obviously, there will be some overlap between some of the concept papers; this is perhaps unavoidable.

## *Annex 1. Concep papers*

### Concep paper 1: Background Information on Aquaculture Production Needs

*Thuy T.T. Nguyen, C.V. Mohan, Michael Phillips, Sena S De Silva*

#### ***Preamble***

The information provided hereto is expected to help us proceed through the workshop in identifying major issues and determining the appropriate research needs- in essence the backdrop to our ensuing discussions. In this document we have attempted to trace the trends in population growth over the years, the current status of wild fisheries, the gap between demand and supply, and the predictions thereof in meeting the future needs. In order to keep the information succinct we have, where appropriate provided graphical information and kept the text to a minimum.

#### ***Trends in population growth***

Historical aspects

The following information is based on two sources[6, 7]. The present population of 6.7 billion is expected to reach 9.2 billion by 2050. The recognized trends are as follows:

- Earth's population grew ten fold from 600 x $10^6$ in 1700 to 6.3 x$10^9$ to in 2003.
- It took from the beginning of time until about 1927 to put the first 2 x $10^9$ on the planet
  - o Less than 50 years to add the next 2 x $10^9$ (by 1974)
  - o Just 25 years add the next 2 x $10^9$ (by 1974)

[6] United Nations Population Programme: http://esa.un.org/unpp/).
[7] Cohen, J.E. 2003. Human population: the next half century. Science, 302, pp, 1172-1175.

- Asia has the world’s highest population, currently estimated at $3.68 \times 10^9$, and expected to reach $4.78 \times 10^9$ by the year 2025

- More than half of the current annual increases occur in six countries, viz. India, China, Pakistan, Bangladesh, Nigeria and the USA

Impacts/ implications of population increases

These are too numerous to enumerate. Suffice is to say the implications will impact on nutrition-food supplies, health, prosperity, demand on natural resources- biological and physical, security, prosperity- living standards, environmental integrity and so on. Contrary to perceived negative implications, increased population might also provide additional human resources to undertake agriculture related livelihood approaches.

### *Food fish demands/ needs*

The demand for fish is growing through out the world; these increases are driven by perhaps two factors:

- In the developed world primarily due to proven health benefits of fish as a food source, and,

- In the developing world, to a small extent for the above reason but mostly it provides an affordable source of animal protein to poorer sectors of the community

Increased availability, improved distribution systems and comparative price advantage over other animal protein sources - red meats - has meant that more people have access to fish at affordable prices.

### *Consumption rates (Asia-Pacific)*

Predicted needs

Table 1: World population increases and future fish demand

| | Population (‘000)* | | % increase | Supply (2001) per capita (kg)** | Supply current (t) *** | 2020 fish demand**** |
|---|---|---|---|---|---|---|
| | 2020 | | | | | |
| Africa | 905936 | 1228276 | 35.6 | 7.8 | 7,066,301 | 9,580,553 |
| Asia (excluding China) | 2589571 | 3129852 | 20.9 | 14.1 | 36,512,951 | 44,130,913 |
| Europe | 728389 | 714959 | -1.8 | 19.8 | 14,422,102 | 14,156,188 |
| Latin America & the Caribbean | 561346 | 666955 | 18.8 | 8.8 | 4,939,845 | 5,869,204 |
| North America | 330608 | 375000 | 13.4 | 17.3 | 5,719,518 | 6,487,500 |
| Oceania | 33056 | 38909 | 17.7 | 23 | 760,288 | 894,907 |
| China | 1315844 | 1423939 | 8.2 | 25.6 | 33,685,606 | 36,452,838 |

| | | | | | | |
|---|---|---|---|---|---|---|
| World | 6464750 | 7577889 | 17.2 | 16.3 | 105,375,425 | 123,519,591 |

Source: UN; **Source: FAO; ***2005 population x 2001 per capita supply; ****2020 population x 2001 per capita supply

Table 2: Role of aquaculture in fulfilling the needs of food fish supplies

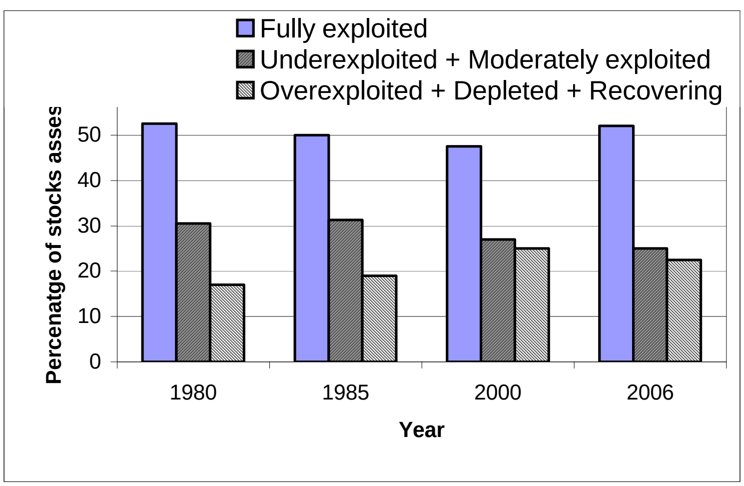
| Forecasts | By the forecast date | | Calculated quantities required from aquaculture by the forecast date | |
|---|---|---|---|---|
| | Global caput consumption | Food fish demand | Growing fisheries (0.7%) | Stagnating fisheries |
| Delgado et al., (2003) (IFPRI ) 2020 Baseline Lowest Highest | 17.1<br>14.2<br>19.0 | 130<br>108<br>145 | 53.6 (1.8%)<br>41.2 (0.4%)<br>69.5 (3.2%) | 68.6 (3.5%)<br>48.6 (1.4%)<br>83.6 (4.6%) |
| Wijkström (2003) 2010 2050 | 17.8<br>30.4 | 121.1<br>270.9 | 51.1 (3.4%)<br>177.9 (3.2%) | 59.7 (5.3%)<br>209.5 (3.6%) |
| Ye (1999) 2030 | 15.6<br>22.5 | 126.5<br>183.0 | 45.5 (0.6%)<br>102.0 (3.5%) | 65.1 (2.0%)<br>121.6 (4.2%) |

(the above two Tables are modified after Siriwardena, P.P.G.S, Stirling University)

## *Fish food supplies*

<u>Capture fisheries stocks</u>

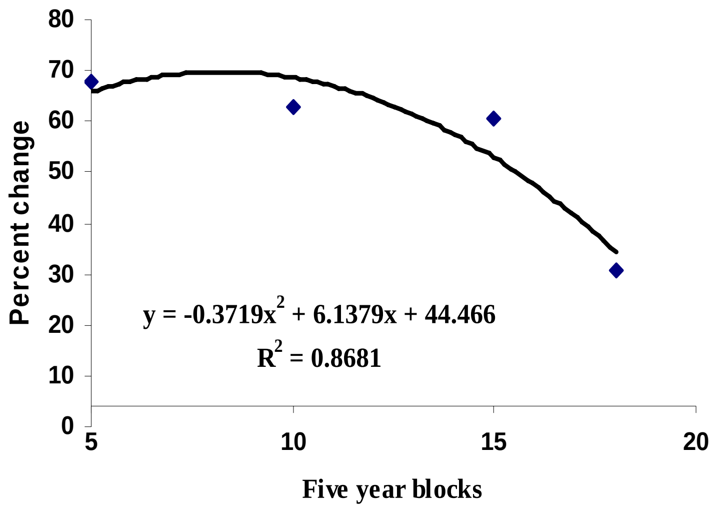
The figure depicts (data from FAO 2007) the dire straits the capture fishery stocks are in currently; the growth of the sector is minimal - if any - and very unlikely to improve significantly. There is, however, some indication that the contribution from inland fisheries could improve (currently estimated to yield 10 x $10^6$ t; 80 % in Asia)[8] through well managed stock enhancement measures and culture-based fisheries development (a form of aquaculture)[9].




[8] FAO, 2007. The state of world fisheries and aquaculture (SOFIA), 162 pp

[9] De Silva, S. S., 2003. Culture-based fisheries: an underutilized opportunity in aquaculture. ***Aquaculture* 221**, 221-243.

## *Aquaculture*




The sector has been mooted as the fastest growing food production sector, globally, over the last few decades, growing at an average rate of 8.0 % /year- a very familiar and a commonly heard “mantra”. Aquaculture currently contributes over 40% to all food fish consumed. The contribution to total supply of aquatic products is expected to increase. Some salient points of Asian aquaculture are:

- Asian-Pacific aquaculture contributes over 85% to global production. This dominance is expected to continue.
- Most aquaculture is small scale; clustered holdings
- Still freshwater finfish is the largest cultured commodity group
- Mariculture is growing rapidly
- The number of species cultured is increasing10
- Increasing intensification
- Continued diversification of species
- Continued diversification of culture systems
- Increasing influence of markets, trade and consumption (food safety)
- Enhanced regulation and better governance to sustain aquaculture
- Increased competition for natural resources, such as freshwater, fish meal and others
- Increasingly integrated aquaculture business structures

## *Growth in aquaculture*

There is evidence to show that, although the absolute production is increasing, the rate of growth is on the decline (see Figure and also the reference Subasinghe, 2006[5]).

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[10] For example, in Asia and the Pacific region 204 species belonging to 86 families are cultured, as opposed to 336 and 245, respectively, globally (Subasinghe, R., 2006. State of world aquaculture: 2006. ***FAO Fisheries Technical Paper* 500**, 134 pp.)

The above mathematical trend is to be expected as production volumes increase (recent population growth follows the same trend). The key question is whether this decline points towards a growing gap between supply and demand- if so, there is a problem, and this is where research comes in; helping to proactive in solving the said problem.

**How do we sustain what is current and or can we overcome the trend of decreasing growth rate in aquaculture (do we need to?)? If so how? What are the main issues that we need to address?**

Some issues for brain storming:

1. Production systems

- farming of species feeding low on the food chain
- exploiting the natural productivity of aquatic systems (farming the seas, enhanced fisheries)
- less dependence on fish meal based feeds and improving resource use efficiency
- integrated systems
- domestication as opposed to wild seed as source of stocking material
- promoting culture of native species
- encouraging responsible introductions

2. Servicing the sector

- Organizing small scale farmers and preparing them to meet the future challenges facing aquaculture

3. Economic development and poverty

- value addition for aquaculture products (please note that this one may not be relevant to production needs, but is more related to economic development through aquaculture – i.e. more value to the producer, or producing country. This is an important issue for development and poverty reduction, rather than production per se).
- role of the sector in economic development and poverty reduction
- market and globalization trends and future competitiveness of small-scale aquaculture farmers

4. Global trade and markets

- equivalence in food safety standards for aquaculture products meant for domestic consumption and export
- national and international standard setting for aquaculture
- implications of international trade and globalization of services, production systems and markets
- future competitiveness of small-scale aquaculture farmers in global markets

5. National and international policy

- effective policies for inland culture based capture fisheries and mariculture in open waters
- role of national and international policy environment for sustainable aquaculture, and role of research in creating the right policies for aquaculture

## Concept paper 2: Climate Changes & Aquaculture Research

*Sena S De Silva and Michael Phillips*

*« It is among those nations that claim to be the most civilized, those that profess to be guided by a knowledge of laws of nature, those that most glory in the advance of science, that we find the greatest apathy, the greatest recklessness, in continually rendering impure this all- important necessity of life…. Alfred Russel Wallace, Man's Place in the Universe, 1903>>*

### *Preamble*

It is not a question of when and if climate change- more floods (in 1960 approximately $7x10^6$ were affected but today the figure is $150x10^6$, annually), more hurricanes, irregular monsoons etc. etc., global warming and sea level rise will occur but to what degree these changes will take place in the coming decades? The reasons underlying these changes are well understood and basically have been driven as a result of industrialization that has brought about changes through excess emission of carbon dioxide, methane etc. into the troposphere and the stratosphere (Fig. 1): for example the atmospheric methane level has increased from 715 ppb in the pre-industrial revolution level to 1775 ppb at present. The average temperature on our planet has been increasing steadily, being accelerated since the dawn of the industrial revolution (Figure 2).

There is agreement that our planet will heat by 1.1°C this century come what may, and business as usual will commit to a $3^{o}$C rise in temperature. Earth's average temperature is around 15°C, and whether we permit it to rise by a single degree or 3°C will decide the fate of thousands of species and most probably billions of people[11]. The Intergovernmental Panel on Climate Change (IPCC) has estimated that the oceans will rise 10 cm to 100 cm over this century; thermal expansion contributing 10 to 43 cm to the rise and melting glaciers would contribute 23 cm. The overall mitigating measures that are being put in place are major political decisions (e.g. Montreal Protocol- CFCs, HCFCs; Kyoto Protocol- $CO_2$) and are beyond the realm of our purview.

Admittedly, to date reported impacts from climate change have been relatively small. Over the past eight years drought and unusually hot summers for example have caused world grain yields to fall or stagnate (but the number of mouths to feed has grown by 600 million). Nevertheless some of the major changes related to global warming that have already occurred and or predicted to occur could impinge on aquaculture development, and are:

- Notably, the Indian Ocean is the most rapidly warming ocean on earth, affecting major changes in ocean and also on land e.g. Sahelian drought[12]; productivity changes and changes of current patterns

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[11] Flannery, T. 2005. The Weather Makers. Text publishing, Melbourne, Australia.
[12] Gianni, A., Saravanan,R., Chang, P. 2003. *Science* 302, pp. 1027-30.

- Biological productivity of the north Atlantic is predicted to plummet 50%, and oceanic productivity world wide by over 20%[13]: major changes to fish meal availability?
- El-nino affects; reduction in fish catches; impact on global fish meal supplies
- Changes/declines in the krill (Euphausid spp.) populations- often mooted as a possible alternative replacement for fish meal in feeds for cultured stocks- in the Arctic and Antarctic waters and these being replaced by species of rather low nutritional value such as salps[14].
- Major changes in biodiversity, leading to extinction of significant number of species. To date the extinction of one species is clearly related to climatic change- the golden toad (Bufo periglenes) from Costa Rica[15].
- Predictions on overall loss of biodiversity are staggering; one of the most notable studies being that of Thomas et al.[16], when extrapolated indicates that at least one out of five living species on this planet is committed to extinction by the current levels of green house gases.
- Coral bleaching is a major cause of global warming and when continued will bring about major changes in biodiversity of coral flora and fauna, loss of most diverse habitats etc. etc.- Australia will be one of the major nations that will be affected and is being affected[17];

### *Food production and climate changes:*

The great majority of studies on impacts of climate changes have been done on potential loss of biodiversity- in relatively specialized habitats- coral reefs, Amazonian forest, alpine areas etc. and mainly on plants and terrestrial food crops[18], but less on fisheries and aquaculture related aspects per se; changes in yields, crop patterns, and the like. Nevertheless, there is increasing recognition of that climate change will have significant impacts on fisheries and aquaculture, and the livelihoods of people dependant on the sector.

### *Climate change and aquaculture:*

The potential scenarios developed by the IPCC forecast - with indications of "confidence" levels – for fisheries in general indicate the following effects[19]:

- Globally, saltwater fisheries production is hypothesized to be about the same, or significantly higher, if resource management deficiencies are corrected. Also, globally, freshwater fisheries and aquaculture at mid-to-higher latitudes could benefit from climate change: **Medium Confidence**
- Local shifts in production centres and mixes of species in marine and fresh waters are expected as ecosystems are displaced geographically and changed internally: **High Confidence**

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[13] Schmittner, A. 2005. *Nature* 434, pp. 628-33.
[14] Atkinson, A. *et al*. 2004. *Nature*, 432, pp. 100-03.
[15] Crump,M. 1998. In Search of the Golden Frog. University of Chicago Press.
[16] Thomas, C.D. *et al.* 2004. *Nature* 427, pp.145-48.
[17] Australia has the highest per capita greenhouse emissions; 25% higher than the US; Australia's growth in emissions over the last decade has been faster than the other OECD countries (Hamilton,C., 2001. Running from the Storm: The Development of Climate Policy in Australia. UNSW Press, Sydney)
[18] FAO Climate Change. http://www.fao.org/clim/default.htm
19 The UN Ocean Atlas. Fisheries and global climate change from http://www.oceansatlas.org

- Positive effects such as longer growing seasons, lower natural winter mortality and faster growth rates in higher latitudes may be offset by negative factors such as a changing climate that alters established reproductive patterns, migration routes, and ecosystem relationships: **High Confidence**
- Changes in abundance are likely to be more pronounced near major ecosystem boundaries. The rate of climate change may prove a major determinant of the abundance and distribution of new populations. Rapid change due to physical forcing will usually favor production of smaller, low-priced, opportunistic species that discharge large numbers of eggs over long periods: **High Confidence**
- There are no compelling data to suggest a confluence of climate-change impacts that would affect global production in either direction. Marine stocks that reproduce in freshwater (e.g. salmon) or require reduced estuarine salinity will be affected by changes in temperatures and the amount and timing of precipitation and on species tolerances: **High Confidence**
- Where ecosystem dominances are changing, economic values can be expected to fall until long-term stability (i.e. at about present amounts of variability) is reached: **Medium Confidence**
- Subsistence and other small-scale fishers who lack mobility and alternatives, and are often the most dependent on specific fisheries, will suffer disproportionately from changes: **Medium Confidence**
- Because natural variability is so greatly relative to global change, and the time horizon on capital replacement (e.g. ships and plants) is so short, impacts on fisheries can be easily overstated, and there will likely be relatively small economic and food supply consequences so long as no major fish stocks collapse: **Medium Confidence**

The predictions to date suggest that sensitivity to global change will vary between fisheries. The most affected will be fisheries in small rivers and lakes, in regions with larger temperature and precipitation change and on anadromous species. They will be followed by fisheries within Exclusive Economic Zones, particularly where rigid access-regulations reduce the mobility of fishers and their capacity to adjust to fluctuations in stock distribution and abundance; fisheries in large rivers and lakes; fisheries in estuaries, particularly where there are species without migration or spawn dispersal; and in the high seas. For example, how would the changes in monsoonal rain patterns, already reported for India[20], impact inland fishery resources, and in turn on aquaculture activities?

Whilst predictions vary widely, there is little doubt that significant changes in fisheries will occur, and some fisheries changes will likely have significant implications for aquaculture.

### *Known direct impacts to date*

The climate, directly and indirectly, obviously plays a critical role in aquaculture, determining the species that can be cultured, biological processes of cultured species, occurrence of pests and diseases and the availability of key natural resources such as water.

[20] Goswami BN, VnnugopalV et al. 2006. Increasing trend of extreme rain events in a warming environment. ***Science*** 314, pp. 1442-1445.

To our knowledge to date there has been only one reported impact from human-induced climatic change on aquaculture, directly. This relates to the smog cloud generated over SE Asia during the 2002 El-Nino, cutting sunlight off by 10% and heat the lower atmosphere and the ocean, that some authors attributed to dinoflagellate blooms that impacted aquaculture in coastal areas, purportedly from Indonesia to S.Korea, purported to be causing millions of $ worth of damage to aquaculture[21].

### *Potential impacts*

The impacts on aquaculture from climate change, as in the fisheries sector, will likely be both positive and negative arising from direct impacts, and indirect impacts, on natural resources required for aquaculture; the major ones being water, land, seed and feed (biodiversity) and energy. As fisheries are a major source of inputs for aquaculture – feed and seed in particular – changes in fisheries caused by global climate change will also flow through into aquaculture systems, particularly in suitability of different areas for aquaculture species, and the availability and prices of resources such as fish protein for fish feed.

Positive impacts might arise from changes in water temperatures leading to enhanced growth rates and changes in the distribution of species and extension of the range of warmer species; and opening up of new opportunities for brackish water aquaculture in flooded coastal deltas (such as the Mekong delta), where agriculture may become non-viable due to saltwater intrusion.

Negative impacts, which will probably outweigh the positive, and might include:

Increased vulnerability of sea-based aquaculture (e.g. cages) to severe weather, water quality changes (e.g. from plankton blooms) and possibly pollutants and other run off from land based sources caused by flooding.

- Increased vulnerability of near-shore land based coastal aquaculture to severe weather, erosion and storm surges, leading to structural damage, escapes and loss of livelihoods of aquaculture farmers. Some of the most sensitive areas will be the large coastal deltas of Asia, which contain many thousands of aquaculture farms and farmers, particularly the Mekong delta, Ganges and Brahmaputra/ Meghna system in India/ Bangladesh and southern China, already highly developed areas for aquaculture. The downstream delta ecosystems are also likely to some of the most sensitive because of upstream changes in water availability and discharge, leading to shifts in water quality and ecosystems in the delta areas.
- Impacts caused by changes in freshwater availability and drought patterns. Changes caused by shifting monsoons, which are predicted to be more variable, and patterns of water availability in inland areas is likely to have profound implications for aquaculture, as well as agriculture. Water availability for aquaculture is already become a serious constraint in several parts of Asia, including China, and climatic shifts caused by climate changes are likely to exacerbate the impacts.

Biodiversity changes in global fisheries, which in some scenarios are predicted to be highly significant, could impact through the limitations on fish meal supplies. Changes in El Nino, for

[21] Swing, T.G. 2003. What Future for the Oceans? Foreign Affairs September-October, pp. 139-52.

example, a major factor in Peruvian fisheries (primary source for a very significant quantum of the raw material for the fish meal industry), have potential to cause major impacts on availability and pricing of fish meal in aquatic animal diets.

- Impacts caused by warmer water temperature will bring about changes in the distribution of cultured species, as well as likely changes in growth patterns and production. The range in which species can be cultured will also likely change, and particularly species currently farmed near the edge of their optimal range (e.g. Atlantic salmon in Tasmania) will likely be most significantly impacted. The other implication of water temperature changes has increased vulnerability to diseases and stress, resulting in increased economic losses.

## *Country and specific vulnerability*

The impacts of climate change will not affect aquaculture in all countries, or indeed all aquaculture farmers, in the same way[22.]

Asia features highly in vulnerability assessments for aquaculture, with the large producing countries of Bangladesh, China, India, Cambodia, the Philippines and Vietnam being particularly vulnerable to climate change.

Vulnerability will also vary between aquaculture farmers, and other stakeholders along the aquaculture "value chain". The poorest producers will have least resources – financial capital, social or institutional support – to be least able to adapt to climate change, and will likely be the most vulnerable.

## *Potential impacts & research needs?*

The potential impacts on aquaculture reviewed above, and potential research needs can be considered from three fronts: all aquaculture, mariculture and freshwater aquaculture.

The most obvious research area is to conduct further studies on the potential impacts of global climate change on aquaculture, developing some of the general assessments into this paper into more quantitative assessments. Further work on adaptations to climate change is also required.

A GIS type approach, which has shown some promise in initial aquaculture vulnerability assessments, may prove further to be of further use at this early stage to overlay the predicted features and locations of climate change with major aquaculture areas and species.

<u>All aquaculture</u>

[22] Neil Handisyde, Lindsay Ross, Marie-Caroline Badjeck & Eddie Allison **(xxx)** The Effects of Climate change on World Aquaculture: A global perspective. Report for DFID http://www.aquaculture.stir.ac.uk/GISAP/gis-group/climate.php

- Impact through the limitations on fish meal supplies and is dealt with in a separate concept paper.
- Would increases in water temperature bring about needs in cultured species, growth patterns?; if so how will these impact on total yield?
- Locations most at risk from climate change, and possible adaptation mechanisms?
- Locations where climate change could bring optimal production and benefit?

Inland aquaculture

- What would be the warming effects on cold water species culture; mountainous regions etc.; will there be a need for alternative species; warm water species areas suitable for culture become restricted and thereby impact on overall production
- Will the reproductive seasons be affected? Needing modifications in hatchery technologies?
- Will the distribution of wild populations get more restricted, resulting in low genetic diversity and impacting on broodstock management/ quality/ therefore seed quality/ overall yields
- Where are the vulnerable locations for extreme climate events and changes in rainfall patterns? What are the mechanisms for adaptation?

<u>Mariculture</u>

- Changes of currents and extreme events; where are the vulnerable locations and how can mariculture adapt; need to consider placement of cages and technologies; the need to work with oceanographers; map new regions for changed locations.
- Ways of combating dinoflagellate blooms and other water quality changes
- Where the most vulnerable brackish water locations and what are are the strategies to reduce vulnerabilities?
- Having identified the key issues for aquaculture, a further research need would be to identify the strategies, including costs benefits of investment and necessary policy to reduce impacts on the sector, and the people whose livelihoods depend on the sector.
- The opportunities for working with other sectors, for example agriculture, and in integration of aquaculture into watersheds and water conservation measures, also need to be further explored.

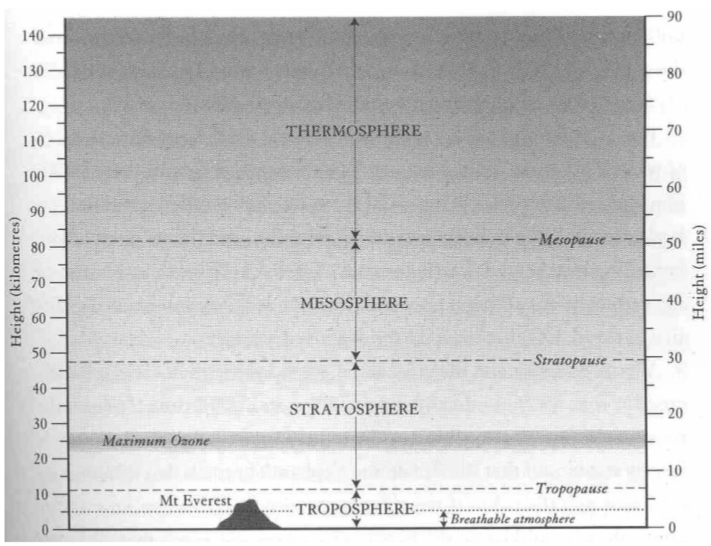
### *Aquaculture and carbon sequestration*

Increasing attention is being given to ways of reducing emissions of carbon dioxide, and even removal of carbon dioxide from the atmosphere. Businesses world wide are looking at reducing their carbon dioxide emissions, and also trading in carbon ‘credits’ in attempts to become “carbon neutral”. In some countries, consumers are also being made increasingly aware of carbon dioxide pollution from the products they consume. To date, aquaculture has not featured in such discussions, but there are some relevant and interesting areas for future research:

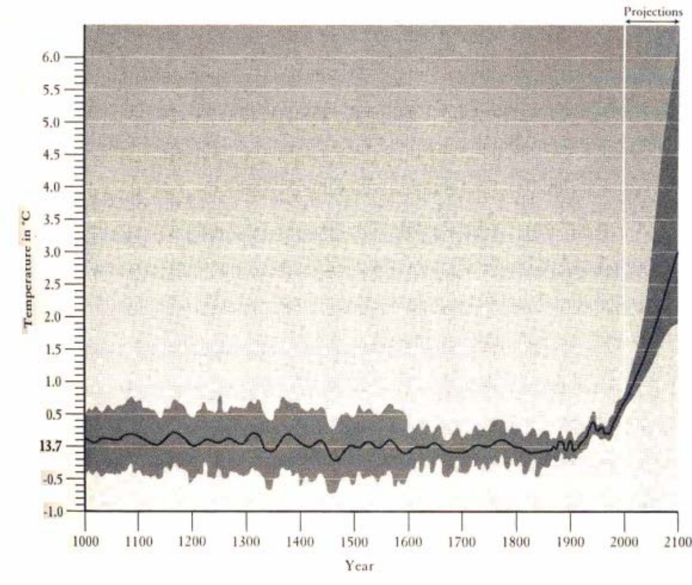
- What is the amount of carbon dioxide released in production of aquaculture products? What is the potential for a carbon neutral food production through aquaculture? Such questions need to be answered through research on the whole farming system, including the discharges and impacts associated with delivery of farmed product to the consumer.

- What is the potential for some aquaculture systems to act as a sink of carbon, thus contributing, albeit in a small way, to efforts to reduce atmospheric carbon dioxide? For example, some recent analyses show significant amounts of carbon dioxide sequestered in the shells of mollusks. If some forms of aquaculture have potential to remove carbon dioxide, permanently, from the atmosphere, then would this open new funding arrangements for aquaculture development through offsetting the emissions of other industries?

The increasing public and business awareness of the concept of “carbon neutrality”, whilst presently focused on carbon dioxide, may also lead to demands that aquaculture (and other food production systems) be environmentally “neutral” in other ways – e.g. in use and discharge of nutrients, in water use – likely leading to increased pressure on the aquaculture industry to implement ever more stringent measures to minimize and control environmental impacts. It is also possible that as aquaculture – along with other industries – is forced to pay for the environmental impacts caused, or at least offset them through carbon and nutrient absorption investments, that some traditional farming systems such as integrated farming may get a new lease of life (see concept note on IFS- the need to increase research from a different perspective). The economics of environmental damage being increasingly highlighted by the climate change debate will inevitably be incorporated into the economics of sustainable aquaculture businesses in the future.



*The four major parts of the atmosphere, and their associated boundaries. Only a small part of the troposphere is breathable air*




*This graph, known as the 'hockey stick', shows trends in the average surface temperature of Earth from AD 1000 to 2100.Prior to 1900 this was 13.7 degrees. The grey area conveys uncertainty, which is reduced around 1850 when the. Thermometer grid was established. The projections on the right give a range of probable temperature increases to 2100.*

## Concept paper 3: Alien Species and Biodiversity in Aquaculture

*Sena S De Silva, Thuy T.T. Nguyen and Simon Funge-Smith*

### *Preamble*

Alien species and biodiversity issues were an academic pursuit for a long time in the past, but became more prominent in association with development and sustainability as a sequel to the Brundtland Report, "Our Common Future' in 1987[23]. Presently, biodiversity impacts are no longer primarily measured through impacts on species disappearance/ displacement, but are now targeted at more detailed issues including; impacts on the genetic make-up of wild species/ strains, resulting from advertently or inadvertently mixing of stocks. This is now considered an equal threat to the simple loss of biodiversity. The impact of alien species/ strains in aquaculture on biodiversity should not be considered in isolation, especially with the envisaged impacts on biodiversity resulting from global/regional/climatic changes and the loss of environmental integrity due to increasing anthropogenic activities. ***Habitat loss or environmental degradation are perhaps most significant in the Asia-Pacific region, which is reputed to have the highest deforestation rate, highest degree of catchment destruction, highest numbers of dam construction, as well as considerable draining and modification of rivers and floodplains etc.[24].***

It is also foreseeable that the current focus on certification, food quality standards and eco-labeling, which are becoming a part and parcel of the importing country requisites of aquaculture produce, will increasingly be expanded to include, acceptably requirements related to biodiversity. ***Asian aquaculture will need to be proactive in this regard and commence introducing mitigating strategies in order to ensure it is adequately covered to remain competitive in the global markets.***

From an aquaculture development view point, it has been suggested that the utilization of alien species, the basis of most Asian aquaculture in the last two decades[25,26,] has significantly impacted biodiversity [27,28,29] even though there is a paucity of direct evidence in this regard. This

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[23] UNEP 1987. Our Common Future. The World Commission on Environment and Development, Commission for the Future. Geneva, Switzerland.

[24] De Silva, S.S., Abery, N.W., Nguyen, T.T.T. 2007. Endemic freshwater finfish of Asia: distribution and conservation status. ***Diversity and Distributions*** **13**, 172-184.

[25] De Silva, S.S., Nguyen, T.T.T., Abery, N.W., Amarasinghe, U.S., **2006.** An evaluation of the role and impacts of alien finfish in Asian inland aquaculture. ***Aquaculture Research,*** **37,** 1-17.

[26] De Silva, S.S**.**, Subasinghe, R.P., Bartley, D.M., Lowther, A. **2004**. Tilapias as alien aquatics in Asia and the Pacific: a review. ***FAO Fisheries Technical Paper*** 453, 65 pp.

[27] Moyle P.B. & Leidy R.A. (1992) Loss of biodiversity in aquatic ecosystems; evidence from fish faunas. In: *Conservation Biology: the Theory and Practice of Nature Conservation* (ed. by P.L. Fielder & S.K. Jain), pp.129-161. Chapman and Hall, UK.

[28] Naylor R.L., Williams S.L. & Strong D.R. (2001) Aquaculture- a gateway for exotic species. ***Science*** **294,** 1655-1666

is partly due to the lack of direct research focus on the issue, in particular, genetic investigations to evaluate impacts especially on the impacts on the gene pools of counterpart natural/ local populations/ species.

The situation is further exacerbated by the fact that the majority of Asian aquaculture is in freshwater, ecosystems which have the greatest vertebrate diversity and are under the greatest threat for loss of biodiversity.

### *Problems and related actions (?)*

In respect of aquaculture developments in the Asia-Pacific region a number of problems can be envisaged and there is a need to address these, urgently. Amongst the needs to be addressed are:

- A thorough evaluation of and assessment of the impacts, including biological, socio-economic and cultural impacts of alien species on aquaculture in the region, and developments of protocols for such future evaluations and continued monitoring.
- Lack of sustained monitoring of influence of impacts of alien species has hampered providing logical and explicit interactions with different "lobby groups", and therefore counteracting the perceived (by the public) "ill effects" of aquaculture developments in the region.
- It is a truism that there is significant degree of ill-informed and ill- conceived translocations for purposes of experimental trials and indeed for commercial aquaculture taking place in the region; how could these be minimized?
    - Is there a need to bring about more stringent policy changes and stricter implementation protocols to be adhered to by all nations in the region?
    - is the current risk assessment processes in place rigid enough/ if not ways of improving these processes?
- Are the stock enhancement processes currently used address long term influences on the genetic pools of native species? If not what should be done; is there a need for a regional program to be developed in respect of such monitoring, and what form should it take?
- A considerable quantum of translocations associated with the aquarium industry sector occurs in the Asia-Pacific region. The impacts of such translocations have received scanty attention to date, even though there have been instances of aquarium species establishing and impacting the environment and biodiversity, such as for example featherback (Chitala spp.) in Sri Lanka and pacu  in Indonesia.
    - There is an urgent need to undertake such studies and also develop a monitoring system and the required protocols
- Often nations are faced with situations that some groups call for a relevant introduction whilst opposed by others. A case in point is the clamour by some to introduce Penaeus

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[29] Naylor R.L., Goldburg R.J., Mooney H., Beveridge M., Clay J., Folke C., Kautsky N., Lubchenco J., Primavera J. & Williams M. (1998) Nature's subsidies to shrimp and salmon farming. ***Science*** **282,** 883-884.

vannamei into India, primarily based on the success of the introduction of this species for example in Thailand, which transformed the shrimp farming sector in the latter[30.]

- How does one proceed in such cases, apart from the application of current risk assessment protocols?
- Is the application of risk assessment protocols by themselves sufficient to ensure long tem impacts of a translocation on biodiversity?
- If not what needs to be done?

[30] Briggs, M., Funge-Smith, S., Subasinghe, R., Phillips, M. 2004. Introduction and movement of *Penaeus vannamei* and *Penaeus stylirostris*. RAPA Publication 2004/10, 79 pp.

## Concept paper 4: Broodstock and Genetic Resources Management in Aquaculture

*Thuy T.T. Nguyen*

### *Preamble*

The growing market demand for fish at a time of declining supply from the traditional capture fisheries has spurred considerable interest in aquaculture. Currently, Asia is considered the epicenter of global aquaculture, accounting for over 85% of global production and likely to continue its dominance well into the foreseeable future.

However, the aquaculture sector is facing public criticism about its impacts on biodiversity. Such impacts involve the risks associated with trans-boundary movements of species and strains, and release or escape of hatchery-produced seed which may dominate and displace the local counterparts.

Lack of understanding and appreciation on the importance of genetic resources has hampered the development of logical and appropriate management actions. The lack of coherent aquatic genetic resources management and of policies is becoming a serious problem because the recent rapid expansion of aquaculture and the overexploitation of many wild stocks have involved irresponsible use of natural resources and lack of consideration of the needs of other sectors, resulting in adverse environmental and social impacts, inter-sectoral conflicts and unsustainability. The bulk of aquatic genetic resources have not yet been characterized and it is a truism that information on aquatic genetic resources, even of major cultured species in the region, is inadequate.

In broodstock management in aquaculture, if attention is not paid on genetic issues as a part of aquatic genetic resources management, often lead to inbreeding and alteration of the genetic make-up in cultured stocks. This in turn could alter the gene pools of the wild counterparts. It is noted that the genetic make up of most cultured populations has often been altered through inbreeding, selective breeding, domestication and more recently through genetic modification such as transgenics. Such impacts in fact have been well documented in the last decade, particularly in respect of salmonids in North America[31]. In Asia, evidences of genetic deterioration and contamination in hatcheries as well as impacts of hatchery-produced stocks on the wild stocks have also become available[32, 33].

Development of strategies for improved hatchery-broodstock management practices is an important step in any aquaculture operation. Such strategies are necessary to minimize the potential impacts of hatchery-produced seed on the natural gene pool. On the other hand, these

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[31] Hindar, K., Ryman, N., Utter, F., 1991. Genetic effects of cultured fish on natural fish populations. *Canadian Journal of Fisheries and Aquatic Science* 48, 945-957.

[32] Senanan, W., Kapuscinski, A.R., Na-Nakorn, U., Miller, L., 2004. Genetic impacts of hybrid catfish farming (*Clarias macrocephalus* x *C. gariepinus*) on native catfish populations in central Thailand. *Aquaculture*.

[33] Kamonrat, W. (1996). Spatial Genetic Structure of Thai Silver Barb *Puntius gonionotus* (Bleeker) Population in Thailand. Ph.D. Thesis, Dalhousie University, Halifax, Canada.

strategies could also optimize the production performance of hatchery produced eggs and larvae and as such satisfy the increased demand on good quality seed. Furthermore, establishment of a high-quality hatchery broodstock will reduce dependence on annual capture of wild brood fish and reduce inter-annual variability in broodstock condition. It also permits manipulation of their reproductive cycle resulting in the capacity for multiple annual spawning, increased hatchery and production, and improved economics.

As with the increasing development of aquaculture in Asia, demand on healthy seed would also increase. In addition, pressure from importing countries on biodiversity issues indicates the need to develop aquaculture in a sustainable manner. This could be achieved through proper genetic resources management in all countries in the region where aquaculture is practiced.

### *Problems and appropriate actions*

- One of the foremost problems facing the management of aquatic genetic resources today is the lack of information, especially genetic structure of many species, particularly in Asia. This is mainly due to inadequate research capacity in obtaining information on genetic resources, as well as in development appropriate management strategies based on information thereof. Although some information on genetic resources is available, but it is relatively incomplete and scattered compared to information on genetic resources of plants34. Furthermore, currently there are no existing aquatic biological databases that give adequate coverage to aquatic genetic resources. As such there is a need to improve information systems on aquatic genetic resources, this will necessarily involve better:
    - Capacity building in genetic resources assessment/ characterisation
    - Characterisation of genetic resources of economically important/ cultured species, and species of conservation value. E.g.
        - grouper species (extensive translocations occurring)
        - Major carp species
        - Selected indigenous fish species with culture potential
    - Information reporting
    - Coordination among researchers, countries and institutions
    - Should INGA be revived?
- Lack of coherent policy on genetic preservation at species level, and as such there is a need to develop an regional policy framework for management of aquatic genetic resources through analysis of the FAO Code of Conduct for Responsible Fisheries (CCRF):
    - The FAO CCRF is the world's most comprehensive and internationally agreed set of principles and guidelines applicable to the management and development of aquaculture and capture fisheries. However, there are gaps in its coverage as well as gaps in other international instruments that deal with aquatic genetic resources. For example, while covering well general fish genetic resources issues, CCRF has not yet been supplemented with a technical guidelines publication that gathers together and amplifies principles and practices for management of fish genetic resources. In addition, recent advances in molecular

[34] www.croptrust.org

genetics and genomics and their implications for fish genetic resources are not currently adequately covered by any of the CCRF guidelines.
    - It is therefore timely that the FAO CCRF needs to be revised and updated to cover the above issues

- Similarly, no technical guidelines are available for broodstock management in aquaculture. The only technical paper available to date is of Tave (1999)35, which deal greatly with aspects of inbreeding in captivity but does not take into account information on available genetic resources. In addition, broodstock founding process and broodstock management for aquaculture are often conducted in a haphazard manner, i.e. does not based on knowledge of basic genetic information of targeted species.
    - More comprehensive guidelines on broodstock management need to be developed, step-by-step from procurement of broodstock that takes genetic and distribution information into account, and management of broodstock in hatchery so that genetic diversity is maintained.
- Similarly, in the case of stock enhancement, genetic diversity is crucial and there is no available guideline in this regard.
    - Special guidelines for broodstock management for stock enhancement need to be developed, including impact monitoring assessment.
- Risk assessment procedures/ guidelines of translocation involving movements of fish from a population to a new location within species distribution range, including movements between hatcheries, are currently not available. Only risk assessment guidelines for release of GMO are available in the ASEAN countries.
    - Appropriate risk assessment guidelines should be included in risk assessment procedures, taking into account the risk associated with movements of aquatic animals to a new location within species distribution range

[35] Tave (1999). Inbreeding and brood stock management. *FAO Fisheries Technical Paper* No.392. 122 pp.

## Concept paper 5: Aquaculture and Human Health hazards-Emerging Issues

*Peter Edwards and C.V. Mohan*

### *Introduction*

This concept paper attempts to provide some background information on this topic and address some of the emerging issues that have come to the forefront since the outbreak of major global disease events such as BSE and bird flu. The concept paper is developed to stimulate research ideas to address such emerging issues in the future.

The issue of safety and quality is of concern to all consumers in both producing and importing countries. Food safety must be an integral part of any aquaculture production system. In most fish exporting countries, special attention is paid to the safety of products meant for export, while products for domestic consumption receive less attention. This trend needs to be rectified through appropriate awareness and capacity building activities and supporting legislation.

This concept paper is presented in 2 sections. The first, deals briefly with the well known food safety hazards associated with fishery products including from aquaculture. The second section deals with some of the emerging issues that may have an impact on aquaculture.

### *Human health hazards from aquaculture*

Potential risks to human health and food safety from aquaculture products can come from various reasons. Food-borne parasitic infections, food-borne diseases associated with pathogenic bacteria and viruses, residues of agro-chemicals, veterinary drugs and heavy-metal organic or inorganic contamination have been identified as possible hazards in aquaculture products[36]. These hazards are usually associated with the aquaculture habitat, the species being farmed, the general condition of the local environment, and cultural habits of food preparation and consumption[37].

Human parasitic infestations caused by fish consumption is widespread. Around 40 million people in Asia are affected by fish and water borne parasitic diseases, especially trematodes. These are widespread in countries where consumption of raw fish is common (e.g. mainly in China, Viet Nam, Thailand and Laos). Of the three types of food-borne parasites (e.g. nematodes, cestodes, trematodes), trematodes are of greatest significance. Fish-borne trematode disease is endemic over a large area of the world, including East and Southeast Asia and Russia. WHO indications are that more than 50 million people may be suffering. Although the disease is seldom fatal, trematodes can cause serious complications in humans leading to fatalities. Use of human and animal wastes for fertilization of fish ponds and the continuation of

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[36] Garrett, E.S., M.L. Jahncke and C.A.M. Lima dos Santos. 1997. Public and animal health implications of aquaculture. Paper presented at the International Life Sciences Institute Conference on Emerging Foodborne Pathogens: Implications and Control, Alexandria, Va., USA, March 1997

[37] Reilly, P.J.A. 1992. Review of the occurrence of Salmonella in cultured tropical shrimp. *FAO Fisheries Circular* No. 851. Rome, FAO. 19p

traditional food habits tend to sustain the parasitic infections. Control requires more research on the epidemiology of infection, better means of identification of infested fish and better diagnostic methods.

There is increasing incidences of reported cases of food borne illness throughout the world associated with aquaculture products. Despite the incidence of food poisoning caused by fish, the safety of fish products carrying bacteria and viruses that are recognized as human pathogens is often questioned. The list of organisms includes: *Vibrio cholerae, V. parahaemolyticus, V. vulnificus, Salmonella, Shigella, Listeria monocytogenes,* pathogenic varieties of *Escherichia coli, etc.* To ensure food safety it is important to understand which of the organisms are indigenous and which contaminants are. When harvested in a clean environment and handled hygienically until consumption, aquaculture products are very safe. Unfortunately, unhygienic practices coupled with insufficient refrigeration and sub-standard processing practices can be at the origin of many outbreaks of fish-borne illnesses. It should be noted that non-indigenous bacteria of faecal origin can be introduced into aquaculture ponds via unavoidable contamination by birds and terrestrial animals associated with farm waters, in systems in which manures are not used for nutritional input.

Molluscs present a higher risk of causing human illness from bacterial or viral pathogens than do crustaceans and finfish. The greatest number of seafood-associated illnesses is from consumption of raw molluscs harvested in waters contaminated with raw or poorly treated human sewage[38]. Human viral diseases caused by the consumption of finfish and crustaceans appear to present a low risk, while viruses causing disease in fish are not pathogenic to man[39]. Filter feeders (e.g. oysters, mussels) can accumulate biotoxins (e.g. PSP) and become harmful to consumers. The extent of accumulation of these toxins by finfish and crustaceans in aquaculture production facilities is still not clear.

Chemicals and antimicrobials are used to treat culture water and fish to control diseases and pests. There is global concern about the consumption of low levels of antimicrobial residues in aquatic foods and the effects of these residues on human health. Plasmid-mediated antibiotic resistances among bacteria found in fish farms, and transfer of this resistance to organisms not directly in contact with the antibiotics are being increasingly reported. The increasing frequency of resistance has been associated with the excessive use of antibiotics in intensive aquaculture systems. The resistance can easily be transferred both to fish pathogens and human pathogens. The danger is that illnesses in humans caused by antibiotic-resistant organisms derived from aquatic products, or the environment of aquaculture systems, might not respond to medical treatment[40]. Emergence of antibiotic resistance should not be only associated with aquaculture practices. It is necessary to closely look into the widespread misuse of antibiotics in the medical and veterinary fields.

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[38] Ahmed, F. E. 1991. Symposium on issues in seafood safety. Institute of Medicine. Washington, National Academy Press. 239p.

[39] Hackney, C. R. and M. D. Pierson. 1994. Environmental indicators and shellfish safety. New York, Chapman & Hall. 523p

[40] Howgate, P. 1997. Review of the hazards and quality of products from aquaculture. Paper presented at the meeting of the Joint FAO/NACA/WHO Study Group on Food safety Issues Associated with Products from Aquaculture, Bangkok, Thailand, 22-26 July 1997

Aquaculture product also carries a risk of contamination from agro-chemicals, especially heavy metals and chlorinated hydrocarbons. Unfortunately, there is little information on their levels in cultured fish to allow risk assessment.

### *Emerging human health issues associated with aquaculture*

Aquaculturists have too often been blamed as adopting a “bury-your-head-in-the-sand” attitude when it comes to human disease threats. There are concerns that increasing intensification of aquaculture practices and its integration with other live stock may give rise to new problems and provide ideal circumstances for the emergence and/or spread of new human pathogens. In view of the recent speculation of bird flu virus transfers as a result of proximity to aquaculture or through integration of livestock and aquaculture, a detailed account on bird flu (H5N1) and its likely implications on aquaculture is provided below.

### *Bird Flu and Aquaculture*

Highly pathogenic avian influenza (HPA1), commonly known as bird flu, is mostly caused by the H5N1 strain of type A virus from the Orthomyxoviridae virus family. It is highly pathogenic i.e., easily spread, among both domestic fowl and wild birds. Flock mortality rates often excede 50% although domestic ducks sometimes carry the virus asymptomatically. Infected birds excrete the virus in high concentrations in faeces and discharges from nose and eyes.

There is also major concern about the zoonotic impact of HPAI. The global WHO tally for human infection on 2 April 2007 was 288 cases with 170 deaths (59% mortality rate). Furthermore, there is a danger that a new strain may evolve that could be readily transmitted among humans. Estimated deaths that could be caused by a new influenza pandemic range from 2.0 – 7.4 million people.

FAO has classified poultry production systems into four sectors in relation to the probability of birds becoming infected with HPAI (Table 1)[41]. Farm management (biosecurity – bio-exclusion refers to measures to exclude infectious agents from uninfected premises) and the system used to market products are the two system variables :

- sector 1: industrial vertically integrated systems with high-level biosecurity and birds/products marketed commercially; farms are part of a vertically integrated production enterprise with clearly defined and implemented standard operating procedures for biosecurity
- sector 2: commercial production systems with moderate to high biosecurity and birds/products usually marketed commercially; in sectors 1 and 2 birds are kept indoors continuously, strictly preventing contact with other poultry or wildlife
- sector 3: commercial production systems with low to minimum biosecurity and birds/products usually entering live bird markets; birds are in open sheds and may spend time outside the shed

[41] FAO, 2004. FAO recommendations on the prevention, control and eradication of highly pathogenic avian influenza (HPA1) in Asia. FAO Position Paper, FAO, Rome. 49 pp

- sector 4: village or backyard production systems with minimal biosecurity and birds/products consumed locally.

Bird infection is most likely in sectors 3 and 4 but when sectors 1 and 2 get infected then there is a greater impact because of the larger number of birds. Adverse macroeconomic impacts are greater for major poultry exporting countries such as Thailand, with microeconomic impacts greater for countries with the poultry sector dominated by small-scale producers such as Cambodia, Laos and Vietnam[42].

It has been stated that in many Asian countries there is a strong link between poultry and fish farming[43]. However, poultry are traditionally raised in scavenging flocks in the region (sector 4), with little to no horizontal integration with fish as bird manure is difficult to collect to fertilize fish ponds. With the relatively recent development of feedlots, raising chickens and ducks adjacent to or over fish ponds has developed to varying degrees in several countries (sector 3). As indicated in Table 1, sector 3 is the only one with relevance for direct horizontal integration with aquaculture although there is no firm information that poultry/fish direct integration has been involved in any HPA1 outbreak.

Table 1. Classification system for poultry production systems (FAO, 2004) and relevance for aquaculture

| | Sector 1 | Sector 2 | Sector 3 | Sector 4 |
|---|---|---|---|---|
| System | Industrial, integrated | Commercial | Commercial | Village, backyard |
| Bio security | High | Moderate to high | Low to minimal | Minimal |
| Bird and product marketing | Commercial | Usually commercial | Birds usually sold in live markets | Birds and products consumed locally |
| Relevance for aquaculture | | | | |
| - direct integration | None | None | Low to high | Minimal to none |
| - indirect integration | Low to moderate | Low to high | Low to high | Low to moderate |

There are two major types of integrated chicken/fish farms in Central Thailand: broiler and layer farms[44]. Broiler farming is exclusively on a contract basis with large companies providing day-

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42 Rushton, J., R. Viscarra, E.G. Bleich and A. McLeod. Impact of avian influenza outbreaks in the poultry sectors of five South East Asian countries (Cambodia, Indonesia, Lao PDR, Thailand, Vietnam) outbreak costs, responses and potential long term control. TCP/RAS/3010. FAO, Rome. 25 pp.

43 Feage, , C.J., 2006. Fish farming and the risk of spread of avian influenza. Wild Wings Bird Management. BirdLife International. 11 pp. http://www.birdlife.org/action/science/species/avian.flu/index.html

44 Belton, B., P. Edwards, J. Hambrey, K. Kaewpaitoon, D.C. Little, W. Turner and J. Young. 2005. Development and trends in the aquaculture production and marketing of Central Thailand. DFID AFGRP, University of Stirling. 109 pp

old chicks and feed and buying back birds at harvest, much for export. Layer farms operate independently and sell eggs to middlemen for the local market. Both are open systems not screened from the wider environment. Following the late 2003/early 2004 bird flu outbreak and slaughter of many birds in infected areas, contract farming companies stopped providing day-old chicks to broiler farmers operating open systems even though the Department of Livestock allowed some broiler farms to reopen after inspection as semi-closed systems with poultry quarters screened with plastic netting. Only layer farms appear to have been able to continue integration with fish in Central Thailand.

The Thai Government policy concerning the meaning of closed system as it relates to fishponds remained to be fully defined[4]. Without poultry manure farmers were unable to raise fish at relatively low cost.

HPA1 led to increases in prices for fish as well as beef and pork in early 2004 as many consumers were wary of consuming poultry products[2].

It is unlikely that HPA1 could infect cold blooded fish. There is rapid die-off of human enteric viruses in manured, green water ponds. According to WHO, human enteric viruses are only of low to medium relative importance in human excreta and wastewater-fed fish ponds[45]. The same should hold for poultry manured ponds. It is thus unlikely that HPA1 would be transmitted passively by fish to either birds or humans.

Poultry by-products are also used to feed fish indirectly via feather meal and by-product meal as ingredients in formulated feed. The potential for HPA1 virus transmission is unlikely because of high temperature in pelleted feed manufacture. Poultry bones from slaughterhouses are ground up to feed *Clarias* catfish in some countries in the region which could disseminate viruses in the environment.

According to FAO, “all commercial poultry farms should develop and implement a formal biosecurity plan as appropriate to the farm”[1]. However, FAO recognizes that banning feeding of farmed fish with poultry manure or poultry by-products might not be feasible for small-scale farmers who rely on poultry and cannot afford pelleted feed. There would be little likelihood of such bans being effective or practicable. Under such circumstances, a “targeted vaccination campaign for poultry at risk of being infected may be required in heavily infected countries”[1].

### *Aquaculture feeds and human health*

Use of organic manures as feed and fertilizer in fish ponds has always been speculated to be responsible for transmitting some of the human pathogens (e.g. Salmonella). Another area that has attracted recent attention is the use of bone meal in fish feeds. This is more so in view of the BSE outbreaks and the spread of the BSE pathogen in bone meals.

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[45] WHO, 2006. Wastewater and excreta use in aquaculture. Guidelines for the safe use of wastewater, excreta and greywater. Volume 3. WHO, Geneva. 140 pp

### *Other areas of concern*

Other areas of concerning include aquaculture increasing the risk of insect vector borne disease in humans. Poorly-managed fish ponds or abandoned fish ponds are suggested to become mosquito-breeding sites. Small impoundments greatly increase the overall aggregate shoreline of ponds, causing higher densities of mosquito larvae and cercaria, which can increases such as lymphatic filariasis and schistosomiasis, respectively. In addition, multi-species livestock production (e.g. pigs and poultry) integrated with aquaculture are thought to assist in possible mutations and spread of pathogens like bird flu virus

### *Problems and related actions (?)*

- To what extent are poultry integrated with fish, in what ways and to what extent have the practices been influenced by HPA1 virus? Studies have only been carried out on the implication of HPA1 to free range ducks in Indonesia[46] and Vietnam[47]. The proposed study could be incorporated in a study to be carried out by FAO on small-scale poultry production and HPAI virus[48].
- How have fish prices responded to lower supply and demand of poultry caused by HPAI outbreaks?
- How long does HPA1 virus survive when infected poultry manure is added to fish ponds (or spread on fields)?
- Do fish become infected with HPAI virus and excrete the virus?
- To what extent are poultry by-products used in aquafeeds on-farm as well as in industrially formulated feeds? Is HPA1 virus killed in the process? Are such feeds imported/exported?
- Can the potential hazards at the production level be controlled by good farm management practices, and consumer education?
- Can the HACCP system be applied from production to consumption in the aquaculture sector to control food-borne hazards?
- In view of the large number of aquaculture commodities produced in the Asian region, can practical HACCP plans be developed for key commodities (e.g. shrimp, carps, catfish).
- Can the principles and concept of risk analysis be applied as basis for assessing, managing and communicating risks associated with food-borne hazards?

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[46] CIVAS/FAO, 2006. A review of free range duck farming systems in Indonesia and assessment of their implication in the spreading of the highly pathogenic (H5N1) strain of avian influenza (HPA1). Final Report. CIVAS, Jakarta and FAO, Rome. 60 pp

[47] Edan, M., 2006. Review of free-ranging duck farming systems in Northern Vietnam and assessment of their implication in the spreading of the highly pathogenic (H5NI) strain of avian influenza (HPA1). Final Report. VSF-CICDA and FAO, Rome. 75 pp.

[48] FAO, 2007. Review of small-scale poultry production practices and its contribution to gender equity, food supply and food security, income generation and rural development. Proposed study FAO, Rome. 2 pp.

## Concept paper 6: Integrated Fish Farming

*Sena S De Silva & Miao Weimin*

### *Preamble*

Integrated fish farming (IFF) systems, combining livestock and agriculture crop production systems with farming of fish and other aquatic products are traditional farming systems, originating largely in China that have evolved over 2000 years. IFF systems have been viewed as environmentally friendly, making efficient use of water and organic material and nutrients derived from various livestock, poultry of agricultural crop wastes. They are also a low risk and sustainable method of food production suitable for small-scale producers in rural areas of developing countries. Through the pioneering work of IDRC[49] and other donors, the systems originating in China have now been widely adopted throughout many developing countries in Asia, creating much needed fish production and income for many thousands of small-scale farmers throughout Asia. They are recently also being promoted in Africa through pioneering south-south cooperation supported by the Chinese government.

Times are changing though for this important rural food production system; economic change in China is causing massive shifts in the farming systems as farmers orient towards high value crops; and increasing questions are being raised about the safety and future of certain integrated fish farming models, particularly fish farming directly integrated with livestock and poultry. The emergence of global health concerns, such as avian influenza, has focused attention on the bio-safety of integrated fish farming The discharge of livestock and poultry manure, the proximity of high densities of livestock close to common water reservoirs, and easy access of migratory birds to ponds has led some to postulate that integrated farming systems are a risk to spread of avian influenza. Production of aquatic animal protein based on livestock and poultry manure is also being questioned because of human health concerns related to transfer of antibiotics and growth promoters from livestock and poultry into the food chain, food safety of the final product from microbial and chemical contaminants, and risks of transmitting fish borne zoonotic parasites from the livestock manure into fish destined for human consumption.

On other hand, there has been positive development in integrated fish farming in the past couple of years. Good examples include the integration of biogas generators for “clean and biosafe” use of livestock wastes, instead of direct discharge into fish ponds.

There is therefore a need for an analysis of the status and risks from integrated fish farming, and the development of scientifically based guidelines for its practice and future development. Environmentally sound and biosafe practices in integrated fish farming in the regions need to be identified and guidelines prepared to support responsible development of IFF systems. There is a need for the IFF systems which operate in rural areas and providing a basis for thousands of livelihoods to be improved upon if it were to meet the demands of the coming decades and beyond. With appropriate improvements brought about through R & D, IFF could be model for a rural based, low intensive “organic farming system”. Also, considering the fact that the IDRC in

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[49] http://www.idrc.ca/en/ev-27162-201-1-DO_TOPIC.html

the late 1980s to early 1990s was a main provider of funds for IFF R&D and training in the region, which enabled these practices to be improved and sustained, it will be logical for the

### *Needs*

- Assessment of status, benefits and risks of integrated fish farming in China and other selected countries in Asia, with special reference to environmental sustainability and bio-safety.
- Development of scientifically-based guidelines on integrated fish farming practices and management for widespread dissemination at regional, national and local levels.
- Strengthening of south-south cooperation within Asia and between Asia and Africa in promotion of safe and environmentally sound integrated fish farming.

### *Questions to be addressed*

- Integrated fish farming and human health - analyzing present and future hazards associated with human health such as avian influenza, zoonotic parasites, product quality etc. Where are the critical hazards and risks, and how can risk management be improved to reduce risk and improve quality?
- What is the present status and trends of integrated farming systems? How are economic changes in China and elsewhere driving the farming systems? Is this increasing or reducing environmental and bio-safety risks? What are the costs to farmers and society from such changes?
- Environmental issues and IFF – what is the present role of integrated farming systems in water and resource/biodiversity conservation. Is there a future role for IFF habitats in biodiversity conservation? How can the environmental values of integrated farming systems be best captured, whilst minimizing risks?
- What are the market and economic factors driving change in IFF. Are these good or bad for the environment, or consumer? Are environmental benefits of IFF worth more investment in IFF? Can fish and non-fish products from IFF systems be promoted (e.g. through organic schemes etc) so that the environmental and biodiversity benefits be retained. Is there a market for organic products in China, or other markets, from IFF that has not been tapped?
- What are the regulative policy (e.g. effluent discharge) and public sector factors (e.g. extension and technical advisory services to farmers) driving the change in IFF. How have the overall technological development and improvement in aquaculture sector (such as improved accessibility to and better quality of input materials like feeds) impacted on traditional integrated fish farming systems.
- How successful has the transfer of IFF technologies been? What are the constraints in national, regional and inter-regional cooperation efforts? How best can south-south cooperation in environmentally sound and biosafe IFF be facilitated? What are the future opportunities and strategies for promotion of IFF, in Asia, but also opportunities for Asia-Africa extension and cooperation?

## Concept paper 7: Feed Development Needs

*Sena S De Silva*

### *Preamble*

There is a significantly rapid change in emphasis in Aquaculture developments in the Asia-Pacific, mostly dictated by the export markets, increasing of living standards in main aquaculture producing countries in the region, and limitation of physical, non-renewable resources inland. The shift is towards a major emphasis on coastal aquaculture of high valued species, in particular high valued finfish species such as groupers (Family Epinephalidae) snappers (*Pagrus* spp.), seabass (*Lates calcarifer*) together with shrimp (*Penaeus* spp). These species require external feed inputs, either in the form of commercial peleted feeds that have significant quantities of fish meal and fish oil, and or trash/ low valued fish.

Fish meal and fish oil are limiting, expensive resources and the global production of these commodities has almost reached plateau, at approximately 6 and 0.1 million tonnes annually, respectively. The use of these commodities in aquaculture has been increasing and has by-passed all other sectors[50]. Equally, this relatively high degree of usage in aquaculture has been a bone of contention over the years[51,52,53], even though the facts presents in this regard may often been distorted[54].

If the global status is much to be desired in the above regard the scenario in relation to aquaculture developments, in particular mariculture developments in the Asia-Pacific is even of even a greater concern. Some of the salient points[55] based on a regional review are:

- Asia-Pacific is the biggest user of fish meal in aquaculture in the world, estimated at 2,388,058, and 2,096,561 (low) and 3,207,255 (high) and 2-3 x $10^6$ tonnes of trash fish (as direct feed source), currently and 2010, respectively.
- The region, however, produces only 1 x $10^6$ (PR China, Thailand, Myanmar etc.)tonnes of fish meal and is a net importer
- The region produces an estimated 4 million tonnes of trash fish/ low valued fish
- which is used directly and or in non-commercial feeds
- The trash fish/ low valued fish is almost solely used in mariculture, baring some usage as fish powder in animal feeds

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50 TaconADJ., **2004.** Use of fish meal and fish oil in aquaculture: a global perspective. ***Aquatic Resources Culture and Development***, 1, 3-14.
51 New M., **1991**. Compound feeds- world view. ***Fish Farmer***, March/ April 1991: 39- 46.
52 NaylorRL., GoldburgRJ., MooneyH., BeveridgeM., ClayJ., FolkeC, Kautsky N., Lubchenco J., Primavera J., Williams M. ,**1998**. Nature's subsidies to shrimp and salmon farming. ***Science*** **282,** 883-884.
53 Naylor R.L., Goldburg RJ., Primavera J., Kautsky N., Beveridge M., ClayJ., FolkeC., Lubchenco J., MooneyH., Troell M., **2000.** Effect of aquaculture on world fish supplies. ***Nature*** **405,** 1097-1024
54 HardyRW. ,**2001**. Urban legends and fish nutrition, Part 2. ***Aquaculture Magazine*** **27 (2),** 57-60.
55 De SilvaSS, SimYS,TurchiniG (in press). Review on Usage of Fish, Directly and Indirectly as Feed Sources and Feeds in Asian Aquaculture. ***FAO Fisheries Technical Paper***

- The use of trash fish/ low value fish in other feeds for feeding animals reared for non-human consumption is significant (estimated at 2- 3 x 106 t) but has not received global attention

***Immediate problems***

- A need to reduce the reliance on trash fish in the growing mariculture sector
- A need to develop feed standard – there is a mushrooming of small scale feed plants in the region, which do not necessarily adhere to proper feed formulations- the label specifications not reflecting the actual composition; leading to wastage, poor performance, higher costs., more negative environmental impacts
- Feed development for the larval and fry stages of cultured marine species
- Lack of feed standards and complying legislative needs
- Poor feed management practices
- The vast majority of inland fish farming practices depend on "farm made " feeds; - an area which has received scant attention[56,57]- but needs much attention; any improvements to such feeds will have a major impact on utilization of the resources and improved performance of the cultured stocks

***Lessons to be learnt from elsewhere***

The major strides made with respect to salmon feeds; an international collaborative effort; reduce fish meal inclusion by approximately 35%; improved feed utilization efficiency two fold (the average FCR in a properly managed salmon farm is 1: 1); reduced nitrogen and phosphorus discharge

***Research needs?***

- Should there be a regional approach?
- Policy developments; regional guidelines on feed standards?
- Weaning off from direct use of trash fish?

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[56] De Silva, S.S., Davy, F.B., **1992**. Strategies for finfish nutrition research for semi-intensive aquaculture in Asia. ***Asian Fisheries Science*** **5**, 129-144.
[57] New, M.B., Tacon, A.G.J., Csavas, I. (eds.), **1995**. Farm-made aquafeeds. ***FAO Fisheries Technical Paper*** **343**, 434 pp.

# Concept paper 8: Effective Utilization of Inland Water Resources for Food Fish Production

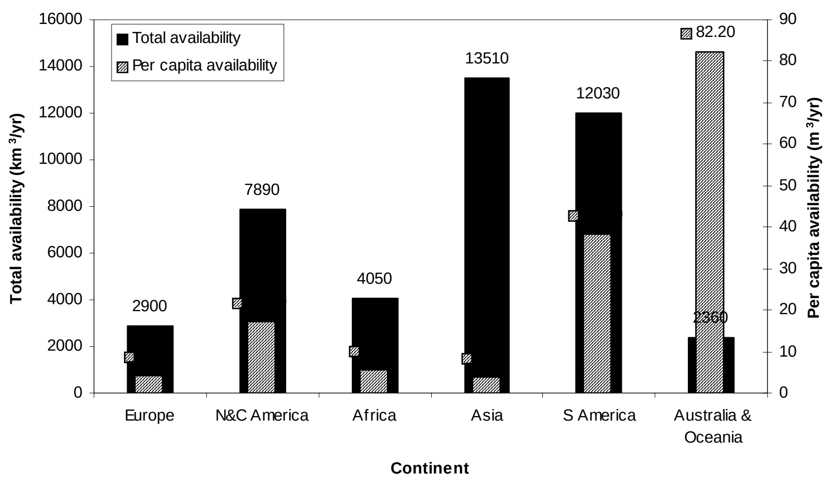
*Sena S De Silva*

## *Preamble*

<u>Water</u>

Inland water is one of the most limiting natural resources on the planet. This planet:

- is estimated to have only 35,029,000 $km^3$ of freshwater, or only 2.5% of all water resources
- of the fw resources only 23.5% is habitable, the rest being ice caps and glaciers[58], [59]
- The amount of fw available as rivers, lakes, wetlands, etc. amounts only to 0.01% of the earth's water resources or only 113,000$km^3$.
- Asia is blessed with the maximum quantity of inland water amongst all continents
- But the amount available on a per capita basis is lowest (Figure 1)[60].




- However, Asia also has the world's highest static/ lacustrine waters, the great bulk being man-made for other purposes; a resource that could be effectively utilized for the secondary purpose of food fish production.

[58] Shiklomanov I .A. 1993. World freshwater resources. In: Gleick P.H. (ed), Water in Crisis: A Guide to the World's Fresh Water Resources. Oxford University Press, New York, pp. 13- 24.
[59] Smith D. I. 1998. Water in Australia. Oxford University Press, Oxford. 384 pp.
[60] Nguyen, T.T.T., De Silva, S.S., 2006. Freshwater finfish biodiversity and conservation: an Asian perspective. *Biodiversity and Conservation,* 15, 3543-3568.

- It is also important to note that the great bulk of such water bodies, perennial and non-perennial are located in rural areas, and these constitute an integral component in the livelihoods of the populations living around the vicinity.
- It is also estimated that water surface area, classified as small scale irrigation schemes, available in developing nations in Asia is 66,710,052 ha[61], a significant proportion of which is considered to be suitable for food fish production, on an extensive basis, but community managed- culture based fisheries[62].

<u>Inland food fish</u>

- Inland fish production is estimated at around 10 x 106 per annum (10% of total), and has been increasing steadily, with Asia accounting for about 70% of this production
- Inland fish is almost always consumed, fresh or processed, but rarely or never reduced into animal feed
- Inland fish accounts for about 20-25% of the animal protein intake, particularly in rural populations in the developing world[63].

### *Problem/ Status*

- In general, and globally, inland fisheries have taken back stage; possibly more often than not because these fisheries are artisinal and do not draw the attention of fishery managers and aquaculturists as a plausible means of significantly impacting on food fish production and or contributing to poverty alleviation.
- Lack of such attention by governments and developments agencies have therefore likely to have contributed to sub-optimal utilization of inland water resources for food fish production, for example this being exemplified in the extreme range in capture fishery production variations in reservoirs in Asia within and between nations (from a high of mean production of about 160- 200 kg ha-1 yr-1, in Sri Lanka to as low as 45 kg ha-1 yr-1 in India and even less in Vietnam).
- The above differences in production ac not be fully accounted for by biological reasons only; reasons fro these differences need to be researched and understood, and appropriate measures introduced to increase fish production.

### *Research needs?*

- A regional approach for bringing about effective utilization of such water bodies for fish production?
- Exchange of expertise
- Management regimes; an assessment/ evaluation of current ones; what improvements are needed
- Address problems/ constraints of seed stock supplies
- Address marketing aspects (high seasonality in inland fish production)

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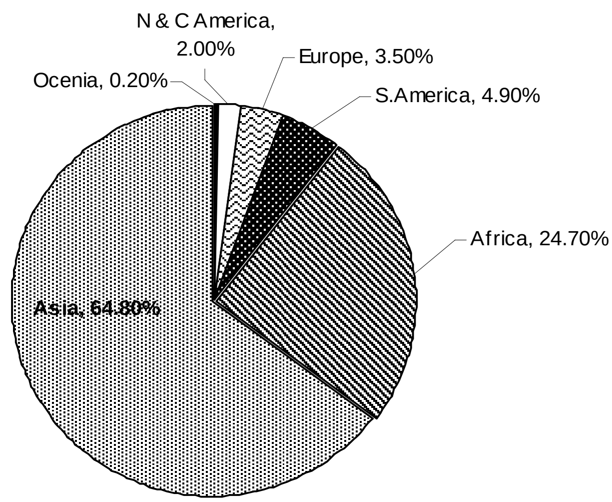
[61] (FAO, 1999b). FAO, 1999. Irrigation in Asia in figures. Water Reports 18, FAO, Rome, Italy, 228 pp.
[62] De Silva S.S. (2003) Culture-based fisheries: an under-utilized opportunity in aquaculture. *Aquaculture* **221,** 221-243.
[63] Delgado C.L., Wada N., Rosegrant M.W., Meijer S. & Ahmed M. (2003) Fish to 2020. Supply and Demand in Changing Global Market. International Food Policy Research Institute, Washington, D.C., 226 pp.

- Value addition?




**Inland fish production by continent- 2004**

## Concept paper 9: Some Socio-Economic and Policy Research Themes

*John Kurien*

What is listed below is basically a random list of themes from a novice in aquaculture for the consideration of the august body of experts who will meet in Rayong **(author's wording!!- not the editors")**

### *Role of state, market and community in planning for aquaculture expansion*

In the Asian region, given the greater scarcity of land and water and competing alternative uses for the same, the decisions on land and water use patterns are best taken in a context where state, market and community are cooperatively involved. Expansion of aquaculture activities should be motivated by the engine of market forces but within a mutually agreed regulatory framework steered by the state and anchored by the community. This can be achieved by participative planning (particularly in the context of the decentralization policies in most Asian countries) which can yield optimal results and greatly reduce social conflict.

### *Aquaculture as a means to maximize the use of scare water resources*

The scarcity of water resources is slated to be the problem of this millennium. In this context the ecological, economic, social and nutritional contribution of aquaculture will be greatest in areas where it can contribute to maximize the sustainable use of scare water supplies. ***If water is considered the limiting factor, then maximizing the returns from a unit of water should be the focus of any development effort in which water use is a central consideration.*** In the context of climate change, the expansion of aquaculture into the large dry zones in Asia can be a beneficial strategy for development of these regions. Needless to say, the type of species choice must be made judiciously. Viewing aquaculture from this perspective may help to identify new areas for its expansion in Asia

### *Factoring protein preferences into demand estimates*

Demand estimates on which much of the discussions about the future role of aquaculture are based need to be more carefully refined. The implicit assumption in most such estimates is that the whole population of a country eats fish. Quantity demanded is estimated by taking an average per capita consumption and multiplying it by the total population of the country (making different assumptions about price behaviour). The varying protein preferences in a country need to be assessed using consumption surveys so as to obtain more realistic demand estimates. Such demand analysis will help to make more targeted projections of the spatial dimensions of demand in a particular country or region. These will not only help to make more refined demand analysis; it will also help in planning for more targeted marketing of aquaculture products.

### *Aquaculture: Food for Nutrition or Luxury Protein?*

Quantity-wise much of Asian aquaculture is destined as food for nutrition in the region. However, in terms of value, much of Asian aquaculture flows to countries outside the region as luxury protein. The economic calculations, ecological implications and social dimensions of these two broad end-uses of aquaculture products need to be compared and contrasted for a meaningful understanding of the trends for the future in each of the countries of the region. Very broadly speaking, aquaculture as food for nutrition is a case of production by the masses for the masses and aquaculture as luxury protein is a case of production by an elite for the elite.

### *Analysis of the sources of growth of the value of exports from aquaculture*

The valuable foreign exchange earnings from exports of aquaculture products are often portrayed in many developing Asian countries as an important reason for the unequivocal support being given to the aquaculture industry. At times the growth rates of the total value of exports can be a misleading indicator because it does not adequately disaggregate the sources of the growth of value. The total change in the value of exports (over any period of time) is made up of growth of value from three sources (1) total volume changes; (2) product composition changes; and (3) price changes. A periodic disaggregated analysis of the total export value into these three sources will give a more realistic picture of the economic and ecological impact of aquaculture export trade. For example, an analysis of sources of growth of total value of exports of marine products from India revealed that over time the greater share in the increased total value of exports came from price changes alone. This could indicate greater vulnerability to external market changes. On the other hand, if in a country, volume changes were the major contributor to total value of exports, we would need to examine the resource sustainability issues more closely. The desirable situation will be to have a balanced contribution by all three sources.

### *The food security impact of regional trade patterns in aquaculture products*

The impact of international fish trade on food security has recently become a subject of concern. In this context there is a direct aspect of food security (fish as food) and an indirect aspect of food security (fish as source of employment and income) which needs to be examined. In the Asian context, there is a considerable (and growing) amount of regional trade in aquaculture products. In this case the direct and indirect aspects of food security are in a more delicate balance because the fish producers, the numerous small traders and the consumers in the countries involved in the trade are largely in the same socio-economic class. Assessing the food security implications of aquaculture in this context deserves special attention.

### *The ecological footprints of Asian aquaculture*

Much controversy has been raised over the ecological impact of Asian aquaculture. This has been particularly worrying in the context of new forms of coastal shrimp aquaculture. The analysis of the ecological impact has been largely concerned with the problems in the immediate vicinity of the shrimp farms. The ecological footprint analysis helps to enlarge the realm of impact analysis to the widest circle of influences so that we can obtain a macro-picture of the ecological impact. ***This would cover inter alia the marine upwelling ecosystem area; the agricultural ecosystem area; the mangrove support area; the carbon sequestering area etc needed for a unit area of aquaculture operations***. Comparison of ecological footprints for different types of aquaculture within a country can also help policy makers to make informed choices on how and when to allocate public investments to help create more sustainable aquaculture practices in the country.

### *The sources and sustainability of fish feed for aquaculture*

The role of the fishmeal trap in curbing the growth of intensive aquaculture is well documented. What is less well documented is the intrinsic link between industrial aquaculture and industrial marine fisheries -- both of which are, from a natural resource perspective, wholly unsustainable.

This linkage is an important cause for the vicious circle of ecological damage both at sea and on land. Very few studies have examined this linkage. Some specific case studies in the Asian region will be instructive to show how industrial aquaculture helps to give a longer lease of life to unsustainable industrial fisheries. The example of trawling in the Gulf of Thailand could be a case in point.

### ***Multi-criteria approach to assess the externalities of intensive aquaculture practices***

Aquaculture activity generates a considerable range of externalities (unintended effects imposed on others without compensating them for the effects) which need to be recognized, assessed and managed if aquaculture is to get a "good name". Externalities can be assessed through a variety of econometric valuation analyses. However, these quantitative assessments are incapable of taking cognizance of valid expressions and understandings about externalities which are qualitative in nature. Valuation exercises which adopt a weighted multi-criteria approach to assessment of externalities need to be more widely practiced in the Asian context. This is needed because the externalities from aquaculture -- particularly the negative, uni-directional and inter-temporal externalities -- affect a very wide cross-section of the population whose valuations (assessments) of these impacts are not always quantifiable in monetary terms. There is always the conflict between the public objectives of economic performance, ecological sustainability and social acceptability – each with different indicators for measurement and languages of valuation. Use of multi-criteria approaches can greatly improve our ability to consider the different perspectives of the large number of stakeholders involved in and affected by Asian aquaculture.

### ***The welfare of workers in intensive export-oriented aquaculture ventures***

The labor absorption capacity of intensive export-oriented aquaculture has been a subject of considerable debate. There are very few good estimates of the number of workers; the nature of their work or their conditions of work. Agencies relating to aquaculture promotion rarely provide a macro picture of work organization; labor conditions or labor productivity in such aquaculture units. We may obtain a good picture of the returns to capital but rarely an idea of the returns to labor in intensive export-oriented aquaculture. With increasing consumer focus on social issues this is a realm which is likely to become an area of contention with implications for export to developed countries. Export promotion agencies and associations of the industry will do well to permit good economic and labor welfare studies being undertaken so that the facts about the welfare of workers are more transparent and better documented. This is the first step needed to improve these conditions.

### ***Factors facilitating the economic concentration of aquaculture production***

Asian aquaculture is generally pictured to be largely small-scale in nature. This may be a valid description of the freshwater culture of products which are largely destined for the internal markets in their respective countries. In export oriented aquaculture (of all types) the tendency for economic concentration has been noticed in most Asian countries. Understanding the dynamics of this and the causes for the same is important. ***Is there a case for aquarian (~agrarian) reforms in aquaculture?*** Does the inverse size-productivity phenomenon, which has been a strong argument for agrarian reforms, valid for aquaculture? What is the relationship between globalization of the aquaculture industry and its economic concentration within the nation state?

## *March of folly: why we don't learn from others' experiences*

It is said that the learning curve can be characterized as an exponential function. Learning is initially slow but rapidly increases with time. ***The boom and bust phenomenon in realms such as shrimp aquaculture highlight that this learning curve is not transferred across countries -- Thailand did not learn from Taiwan and India did not learn from Thailand. Each opted to go through the same boom and bust experience with almost predictable precision.*** This may seem to be irrational behavior of economic agents. However, there is more to this than meets the eye. The economic interests which push for intensive aquaculture are often large industrial oligopolies who are not committed to any particular geographic territory. They are globalized in their pursuit of profit. ***The case of aquaculture feed manufacturers is a case in point --booms and bust are in their interest.*** But to encourage aquaculturists to learn from the (bad) experiences of others is not! Understanding the varied nature of economic interests which promote aquaculture in a country warrants close analysis and study.

## Concept paper 10: Innovations in mariculture (Three Specific Concepts)

*Fatchuri Sukadi*

### *Improving lobster aquaculture as a potential research area*

Justification

The global demand for lobster is growing, and the lobster culture in South East Asia is based on wild collected seed. Global supply of lobster mostly came from capture fisheries. Irrational lobster fisheries will be one of the threats to the sustainability of coral reef ecosystems. In Indonesia, the collection of lobster seeds and growing them in cages is a common activity in Nusa Tenggara Barat (NTB) and started in 2001. The production of lobster from its culture is still low and reached around 60 ton per year. In Vietnam, lobster culture probably is already more advanced. Research on lobster reproduction in hatchery has been done in Australia which is one of the tasks to provide seeds.

The development of lobster culture will contribute to the strategies for aquaculture development beyond 2025. Since lobster culture is a new development of capture based aquaculture in Asia, this activity is included under the strategy of applying innovations in aquaculture, and is that to provide alternative income generations for the poor in coastal areas. Lobster culture is also a means to integrate capture of seeds with its culture and other sources of fisher or farmer income through capture fisheries like *bagan* light fishing. However, the activity of lobster culture, its constraints and opportunity for culture development in Asia and Pacific has not well documented. Hence, study on lobster aquaculture is one of important research area that should be developed in Asia Pacific.

Objectives

The objectives of research on lobster aquaculture are to identify potential areas for lobster culture, species available and being cultured, improvement in seed procurement through hatchery and collection from wild, grow-out techniques, marketing and trade in Asia Pacific region.

Possible countries to be involved

Indonesia, Australia, Vietnam and others. Research Network among related institutions in the regions is required. ACIAR and Vietnam currently has a project relating sustainable tropical spiny lobster aquaculture (Clive Jones, personal communication). Indonesia and ACIAR is formulating the project for smallholder aquaculture development through Support to Market Driven Research.

### *Research on resource efficient farming systems in aquaculture*

Justification

Improving environmental sustainability is an important strategy in aquaculture development. Policies and practices that ensure environmental sustainability are needed.

The development of intensive aquaculture like in shrimp culture or many kinds of fish which located in inappropriate land or coastal areas have made a negatively impacted the environment or to other users. The farmer frequently uses land, water and more input in intensive culture to get high production without any consideration about margin analysis and environmental impacts. Utilization of land, seed, feed inputs efficiently and as suitable for individual species has not been well documented. It is understood that to use species feeding low in the food chain is effective. However, aquaculture of such species is rather limited. There are many more species of seaweed, mollusks and finfish which are still undetermined as good species for culture in efficient farming systems. On the other hand, the integration of aquafarms into marine and coastal area management or inland watershed management plans still has to be established or improved. The exploration of species for aquaculture like seaweed, abalone, sea cucumber and its future trade is important to be made.

Objectives

- To determine ways to make efficient use of water, land, seed and feed input through study on land or marine area suitability and carrying capacity for aquaculture;
- To explore the potential for commercial use of species feeding low in food chain in freshwater, coastal and marine aquaculture.
- To mitigate impact of intensive culture on the environment
- To identify appropriate enhancement techniques

### *Improving food quality and safety in shrimp aquaculture*

Justification

There is now an increasing demand among consumers in importing countries for high-quality, eco-friendly, and safe aquaculture products. However, in becoming an important contributor to the markets, the shrimp aquaculture industry has become increasingly subjected to rigid food safety and eco-friendly production and processing requirements (e.g. Traceability, HACCP, GAP). In the light of these recent trends, small-scale Asian fish farmers, especially in developing countries and countries in transition, have encountered difficulties in meeting such requirements. Therefore, empowering them through technological innovations, guidelines and standards on food safety/traceability, and policy and support services has become necessary to enable them to continue to participate in the network of fisheries and aquaculture production, marketing and trade.

Diet, feeding regimes which applied for safety food product is still need to be investigated. There is still a difficulty on the application of HCCP and traceability in small scale farming practices, and hence the study on possible techniques for these purposes is needed.

Objectives

- To improve diets, feeding regimes and harvesting strategies to enhance product quality and its nutritional value.
- To study the potential role of HCCP and its application to production system, the use of drugs and chemicals at farmer level and appropriate storage technology at middlemen level.
- To assess the existing traceability of product and to study the constraints and opportunity to improve the systems in the shrimp supply chain management those allow good traceability of products, and provide good information on packaging, processing and production conditions.

## Concept paper 11: The successful development of backyard hatcheries for crustaceans: A case study from Thailand

*Hassanai Kongkeo, Michael B. New and Naruepon Sukumasavin*

### *Introduction*

One of the important milestones in **freshwater prawn** farming occurred in the **late 1970s** when the United Nations Development Programme decided to fund a three-year FAO-executed project, named 'Expansion of Freshwater Prawn Farming', in Thailand[64]. This project built on the earlier work of the Thai Department of Fisheries (DOF), led by Somsak Singholka and his team at the Chacheongsao Coastal Fisheries Research and Development Centre (formerly Chacheongsao Fisheries Station) in Bangpakong, Chacheongsao Province. At first it was assisted by one of the pioneers of global *Macrobrachium* culture, Takuji Fujimura, together with visiting FAO project manager, Herminio Rabanal. Michael New was appointed by FAO in 1979 and Somsak Singholka and he co-managed the project until 1981, after which the Thai government continued this initiative. As a result of these efforts, farmed freshwater prawn production expanded from less than 5 t/yr before the project began (1976) to an estimated 400 t by the time it ended in 1981[65]. Soon afterwards (1984), the DOF was reporting to FAO that Thai production had exceeded 3,000 t/yr[66], a very rapid expansion indeed.

This DOF-FAO project not only enabled the establishment of a significant aquaculture sector in Thailand but also benefited the development of freshwater prawn farming globally. One output was the publication of a technical manual on the topic[67,68] that was translated into many languages. In addition, the Thai Department of Fisheries hosted 'Giant Prawn 1980', the first international aquaculture conference ever held in Thailand[69], which was attended by 159 international participants from 33 countries, as well as 200 local farmers. Many Thai experts later advised *Macrobrachium* projects and ventures elsewhere in Asia.

By 2005, the aquaculture production of *Macrobrachium rosenbergii* in Thailand had risen to 30,000 t/yr (valued at US$ 79 million) and to more than 205,000 t/yr globally[70]. In addition, a similar quantity of a related species, *M. nipponense*, was produced in China in 2007. In total, the

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64 New, M.B., 2000. *History and global status of freshwater prawn farming*. pp. 1-11 In: M.B. New & W.C. Valenti (eds), Freshwater Prawn Culture. Blackwell Science, Oxford, England

65 Boonyaratpalin, M.,Vorasayan, P., 1983. Brief note on the state of the art of Macrobrachium culture in Thailand. NACA Working Paper WP/83/7. NACA, Bangkok, Thailand

66 FAO, 1989. *Aquaculture production 1984-1986.* FAO Fisheries Circular, 815. FAO, Rome, Italy

67 New, M.B., Singholka, S., 1985. *Freshwater prawn farming: a manual for the culture of Macrobrachium rosenbergii*. FAO Fisheries Technical Paper No. 225, Rev 1. FAO, Rome, Italy. [Also published in Farsi, French, Hindi, Spanish & Vietnamese]

68 New, M.B., 2002. *Farming freshwater prawns: a manual for the culture of the giant river prawn (Macrobrachium rosenbergii).* FAO Fisheries Technical Paper No. 428. FAO, Rome, Italy. [Also published in Mandarin, with Arabic, French, Malayalam and Spanish versions in preparation]

69 New, M.B. (ed.), 1982. *Giant prawn farming.* Developments in Aquaculture and Fisheries Science, 10. Elsevier, Amsterdam, Netherlands.

70 FAO, 2007. Fishstat Plus, version 2.32. FAO, Rome, Italy. [http://www.fao.org/fi/website/FIRetrieveAction.do?dom=topic&fid=16073]

global farm-gate value of freshwater prawn farming had reached almost US$ 1.84 billion/yr by 2007.

Though there was no seawater available, the Bangkok Marine Laboratory, which has been now allocated by DOF to the Bangkok Fish Market, had successfully cultured ***Penaeus (Fenneropenaeus) merguiensis, P. semisulcatus, P. latisulcatus, Metapenaeus monoceros*** **and** ***M. intermedius*** to postlarvae by **1972**[71]. Seawater had to be brought from offshore by boat. All gravid female shrimp were captured in the Gulf of Thailand. Experiments on pond culture of artificially bred seed were carried out at private shrimp farms in Samutsakorn Province and Bangpoo (Samutprakarn Province), but the results were not satisfactory.

In **1973**, the Phuket Coastal Fisheries Research and Development Centre (formerly Phuket Marine Fisheries Station) sucessfully bred ***P. monodon*** by induced spawning from broodstock caught from the Andaman Sea. Postlarvae of the early batches were stocked in semi-extensive ponds in Bangkrachai (Chantaburi Province), Klongdaan (Samutprakarn Province) and Klongsahakorn (Samutsakorn Province). This brought shrimp farming the much needed technique that enabled farmers to have better control of their crop and sustainable production, instead of reliance only on wild seed for stocking in an extensive culture system. This important research later led to the highest peak of *P. monodon* production of 304,988 mt in 2000[72] before the gradual replacement of *P. monodon* by *Penaeus (Litopenaeus) vannamei* as the major cultured marine shrimp species in Thailand.

### *Hatchery production of crustacean post-larvae*

The major extension thrust in the DOF-FAO project was the provision not only of technical advice but also of free *M. rosenbergii* postlarvae (PL) for stocking the initial grow-out operations on each farm. Freshwater prawns were distributed by road and rail all over Thailand. Large quantities of PL were produced for this purpose in a series of huge concrete tanks sited at the fisheries station in Bangpakong. However, many of its technical staff also began to produce PL successfully in other, less conventional and smaller containers, such as the 'klong pots' used for storing potable water. Before long, some of the stilted houses on the site had small production units underneath their living quarters. Even non-scientific staff learned the necessary techniques quickly. Soon, the first commercial 'backyard hatcheries' began to spring up in nearby areas of Chacheongsao Province. One of the reasons why these backyard hatcheries were to prove so successful was the ability of Thai entrepreneurs to follow changing market requirements. Unlike the massive species-specific hatcheries that were set up in the 1970s and 1980s for fish and crustacean species elsewhere, which were almost impossible to modify, many of these simple backyard hatcheries were easily able to adapt themselves cheaply to produce marine shrimp PL (*P. monodon*) and seabass fingerlings (*Lates calcarifer*), according to demand.

Backyard hatcheries are generally managed with simple but efficient technology, mainly by farmers with little education. The technology that was originally developed for *M. rosenbergii*

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[71] Cook, H.L., 1973. FAO Report to the Government of Thailand on Shrimp Farm Development. FAO Report No. TA 314. FAO, Rome, Italy.

[72] Kongkeo, H., 2006. *Responsible shrimp farming: a critical overview*. p. 358 In: Abstracts of AQUA 2006, 9-13 May 2006, Florence, Italy.

can easily be switched to *P. monodon, P. vannamei*, or the nursery of seabass and grouper fingerlings if prices of existing species drop or disease problems are faced. The initial investment for land, construction and equipment, as well as operation costs is very low because of the simple techniques used. Fortunately, Thai farmers have had a long experience and tradition of aquaculture and crop production. They are also enthusiastic to learn and practise advanced technologies that have been successfully developed at the research scale by government institutions or large-scale entrepreneurs. They always have new ideas for development or modification to suit local conditions and are eager to experiment on their own. Sometimes they start to do experiments on new culture techniques by themselves and learn from their mistakes. The present success of Thailand in the shrimp and prawn industry is testimony to the persistence and ingenuity of Thai farmers in utilising applied science to its utmost potential. It is a good example of blending the results of government research work with farmers' enthusiasm in the adoption of new technology.

Due to the long distance of hatcheries from the sea, hypersaline water from salt farms is transported to them by truck and subsequently diluted to the desired salinity by disinfected freshwater. This hypersaline water is pathogen-free and virus carrier-free, due to its high salinity. These hatcheries purchase *P. monodon* or *P. vannamei* nauplii from nauplii producers who are located near the open sea areas where better water quality is available and the improved circulation needed in the maturation process is feasible. For *Macrobrachium*, hatchery operators use spawners both from grow-out farms and the wild. Small hatcheries run by owners and families are more efficient than the large hatcheries that are run by paid workers, due to the sense of belonging. The decrease in the price of shrimp fry caused by the spread of these backyard hatcheries also helped to stimulate the rapid expansion of grow-out ponds.

When problems occur, production can be discontinued, even for long periods, without undue loss. These family businesses are in contrast to large-scale sophisticated hatcheries, in which the cost of wages, power supply, supporting facilities and other overheads still has to be borne during the closure. Periodic discontinuation of operations is in fact necessary for both hatchery and grow-out, in order to facilitate the reconditioning, drying and disinfection of tanks, ponds, aeration and water systems.

The successful development of small-scale hatcheries was similar to that of small-scale intensive ponds which spread all over the country. More than 80% of Thai marine shrimp production comes from approximately 12,500 intensive farms with a total production area of 27,000 ha[73]. These small operators run one or two ponds, each ranging in size from 0.16-1.6 ha. However, during the early stages of development, large-scale operators are always required to pioneer research work on their own or through the adaptation of new technologies from government or overseas; this serves as a prototype for further development by small-scale operators. The income from operations has also provided considerable socio-economic benefits to these small-scale operators who mainly live in coastal regions. Thus local communities directly gain considerable benefits.

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[73] Kongkeo, H., 1995. *How Thailand made it to the top*. INFOFISH International, 1/95:25-31.

After long development in Thailand, this small-scale hatchery technology has been transferred regionally in order to sustain shrimp production, through the assistance of FAO, NACA, UNDP, the Thai Government, the private sector and feed manufacturers. It has been successfully adapted in Indonesia, Vietnam, India, Bangladesh, and Myanmar. Some countries have modified the technology by using direct seawater because they have had better seawater supply sources.

Over 2,000 small scale hatcheries in Thailand, including those in the Chacheongsao, Cholburi and Phuket provinces, generate a very significant proportion of national production - more than 80 billion/year of marine shrimp post-larvae (90% of the total). They have had sustainable production and survived through many shrimp crises during the past 20 years. It is a shame to learn that they are now suffering from the monopoly in the supply of SPF post-larvae that is held by large-scale hatcheries. These large hatcheries introduced SPF and disease-resistant technologies, biosecure systems, raceway systems, etc., from overseas. To cover their high investment costs, these large-scale hatcheries have to make maximum profit by selling post-larvae directly to grow-out farms instead of selling nauplii to backyard hatcheries as before. The traceability of broodstock and certification, which are now mainly demanded by the developed countries, have also become problems for these backyard hatcheries because they purchase nauplii from nauplii producers. Though nauplii producers can issue PCR-negative certificates, it is difficult for them to sort out the source of origin for individual backyard hatcheries because producers usually mix nauplii from various sources for easy distribution and economy.

The Thai DOF has tried very hard to solve the problems faced by these small-scale operators. A farm registration system and CoC and GAP certification systems have been implemented since 2003. At this moment, 98 and 727 hatcheries have been certified with CoC and GAP standards, respectively, including some backyard hatcheries. Furthermore, the use of the “Movement Document” and tracability system at the grow-out farm level has been recently implemented and is expected to be properly functional and to cover the hatchery level in the next few years. As the fact that overseas SPF technology assures the organism being free of specific disease only in its specific environment, its popularity may decrease if there are more evidences of disease infection similar to cases in Indonesia. At that moment, the opportunity for the backyard hatcheries may return if they are all certified and operated under the traceability system.

## Concept paper 12: Concept Note on Gene Technology in Aquaculture

*K.C. Majumdar*

### *Preamble*

The aquaculture industry is growing at a rate of 9-10% annually whereas capture fisheries has been stagnant for last decade and a half. Global populations increase along with an increased preference for use of crustaceans, molluscs, and fish as food necessitates higher production. To keep the prices of these products under control, which is, set to increase further (about 4%) a concomitant increase in productivity is a need of the hour. By the year 2020, it is expected more than 40% of the total supply will be derived from aquaculture.

Modern biotechnology methods can help reduce the gap between supply and demand. Biotechnology should be used judiciously in 'aquaculture' to increase production. Greater emphasis should be placed in exploring new avenues for pollution-free productivity techniques in aquaculture operations with a reduced overall cost.

Gene technology is being used in several areas to increase productivity in aquaculture. Areas like production, health, disease prevention, species/strain identification, biopharming are chief among them.

### *Production*

**Transgenesis**:  Transgenic organisms have foreign DNA inserted into their genome. Chinese scientists were the first to report results with transgenic fish. They introduced human growth hormone (GH) gene and mouse metallothionein promoter as a chimeric gene construct into the fertilized eggs of gold fish (*Carassius auratus*) by microinjection. Many reports are since available on the success in enhancing growth in different fish species by GH transgenesis. Transgenesis has also been successfully used in fishes for enhancing phosphate utilization, cold resistance, sterility, antibacterial activity etc. Transgenesis is a molecular method that involves isolation of promoter and gene sequences; construction of chimeric transgene DNA fragment; transfer of the transgene into the host genome; detection and quantitation of the transgene copy in the founder population and breeding of founder population to obtain a homozygous stock.

Different types of promoters like constitutive, inducible and tissue specific are available. Before designing the transgenic constructs it is important to decide on the type of promoter to be used in such studies. For example, a constitutive promoter will allow the gene to be functional but at levels lower than an inducible promoter. Although an inducible promoter can make more quantities of the product but it will require an inducer, which will add to the cost of production. On the other hand, tissue-specific promoters are preferred when a gene is to be expressed specifically in a particular tissue. If DNA sequence information is available then Polymerase Chain Reaction (PCR) technique can be used for isolation of the promoter and the gene. Suitable primers can be designed to the desired region of the promoter and the gene with its regulatory regions. If DNA sequence data is lacking, cross hybridization techniques can be used, which will allow identification of orthologous sequences from the desired species.

Once the specific promoter and gene are isolated, then chimeric constructs can be prepared by regular ligation and screening methods. Care should be taken to ensure that the reading frame of the structural gene is ‘in frame’; and that all the regulatory sequences of the promoter and the structural gene are intact and in order.

There are several methods to transfer the chimeric gene constructs into germ cells to obtain a transgenic organism. Techniques like microinjection to nucleus or cytoplasm of eggs, germ cell electroporation, lipofection of germ cells, particle bombardment of fertilized eggs, transfection with retroviral vectors, nuclear localization signal mediated transfer and stem cells modification are popular. Each of these methods has certain advantages and disadvantages that should be kept in mind while making a choice for a certain application. Microinjection of DNA into the cytoplasm has been the method of choice in fishes and has been used extensively like nuclear injection in mammal. This is because the nucleus of the fish egg is not easily visible and so microinjection is done into the cytoplasm, necessitating higher quantities of DNA to be injected. There are reports of other techniques being used to enhance gene integration like attaching the nuclear localization signal peptide to the DNA before microinjecting it into the cytoplasm. A major drawback of this method is the time taken for microinjecting individual eggs. Mass gene transfer methods like electroporation, lipofection of the germ cells or particle bombardment of fertilized eggs, on the other hand, are preferred for its speed but the low frequency of integration of transgene into the host genome can prove to be a hindrance in its use.

In the putative transgenic individuals gene transfer has to be confirmed initially by identification of the presence of the transgene and further by the number of copies integrated in their genome. This can be accomplished by PCR amplification of the target gene from DNA isolated from different tissues of the transgenic individual.

Southern analysis or quantitative PCR can be done for identifying the copy number of the gene. To identify the site of integration, inverse PCR and fluorescence *in situ* hybridization (FISH) can be used where the former method shows contiguity of genomic DNA sequences with the transgene and FISH analysis shows physical localization of the transgene on the chromosome.

Breeding experiments to obtain homozygous transgenic stocks can follow identification of the transgenic founder population. Performance related tests would indicate the superiority of the transgenic individual with respect to the selected character over the wild type individual.

### *Health*

**Pathogen identification**: Disease caused by specific pathogens can be detected by PCR method that identifies the pathogen’s DNA sequence in the DNA isolated from the tissues of the affected organisms. In the absence of such specific information on a pathogen’s DNA sequence, ribotyping can be done to identify the putative infective organism. Quantitative PCR can further determine the levels of infection thereby helping to decide on the course of action to overcome the infection.

**Disease prevention:** Vaccines: Vaccination is among the best methods for disease prevention. In classical vaccination procedures a whole inactivated organism or components of the causative organism are injected to provide immunity. There is a compelling need to identify, isolate and culture the infective organisms for which PCR based techniques can be used in identifying the species and the strain of the microorganism.

- DNA Vaccines: DNA vaccine is an upcoming therapeutic that has the potential to replace or supplement conventional vaccines. In this case the antigen producing gene/DNA sequence is put under the control of a promoter that is active in the tissue, which receives the vaccination. DNA vaccine is produced as a plasmid in a bacterial host; therefore, production of large quantities of vaccine through microbial fermentation technology is easy and economical. Besides, such vaccines do not require refrigeration during transport, which helps in reducing the overall cost. Vaccines derived by this technology can be used conveniently in large fish farms to protect/treat infections.
- RNAi method: RNA interference is another powerful molecular technique that can be used to prevent infections in fish. In this method, the double stranded RNA when introduced into the cells is cleaved into 21-23 bp fragments by 'Dicer'. This double stranded RNA (siRNA) binds with a protein complex forming RNA Induced Silencing Complex (RISC). The ATP-dependent RNA helicase then unwinds the double stranded siRNA into single stranded RNA. The antisense strand guides the RISC to the homologous mRNA, which is cleaved at a single site by an endoribonuclease of the RISC. In future, it is expected that by combining transgenesis and RNAi technology it may be possible to develop transgenic organisms that are resistant to specific viruses.

### *Species/strain identification*

Identification at the level of genus, species, or individuals of a species can be done DNA fingerprinting that depends on the detection of variability in the genome. The DNA fingerprints of different species are being continually upgraded for several varied applications in areas of phylogeny, breeding biology, migration and forensic analysis etc. DNA fingerprinting can be performed by two different methods, either by the hybridization based or by the PCR based. Hybridization based method requires some knowledge of the complexity of the genome whereas the PCR based methods can be done without any prior knowledge of the sequence information. These methods generally deal with the nuclear DNA however recent developments in DNA sequencing have allowed the use of non-nuclear DNA (mitochondria and chloroplast DNA) sequence analysis for the identification of species/individuals. Here, a part or the total genome can be amplified and sequenced for comparison. Analysis of both nuclear and non-nuclear DNA provide information regarding the true identity of the individual/species/strain which have been used to solve forensic as well as controversial IPR issues.

The other types of variability present in the genome are STR (short tandem reports) and SNP (single nucleotide polymorphism). Both these types of sequence markers have revolutionized genome mapping and are being used in marker-assisted selection of commercially important characters. Marker-assisted selection is superior to conventional selection, because individuals carrying the markers can be detected and less number of crossing experiments is required to reach the selection goal.

### *Biopharming*

Genetically manipulated fishes can be used as bioreactors to obtain a specific product. For example polyunsaturated fatty acids are abundant in marine fishes. The gene complex coding for polyunsaturated fatty acids be isolated and incorporated into fishes, which in fresh water aquaculture production will produce the desired product. Besides, similar value additions can be done to fishes, which are not commercially important to make them attractive to the consumers.

### *Priority areas for research*

- Genetically modify organisms used in fish feed for increased nutritional enrichment and as a replacement for fishmeal in the fish feed.
- Genetically modify the colonized gut flora in fish with an aim to increase production of essential amino acids that will reduce its requirements in the feed.
- Gene transfer technology.
- Embryonic stem cells and cloning.
- Bioactive molecules from aquatic sources.
- Genome sequencing.

### *Recommendations and further discussions*

- Research in the above-mentioned areas requires higher technology input. It is possible to set up a few institutions/laboratories that can initiate these projects. Funding can be provided by collaborating countries (with financial assistance from international agencies). The technology when developed can be shared by the collaborative countries and be made available at a price for use by other countries.
- Ethical issues on the use of transgenic organisms for commercial purposes need to be addressed.

## Concept paper 13: Tilapia farming in the Philippines and challenges in relation to rural development

*J.D. Toledo, B.O. Acosta, R.R. Eguia, R. Egui[1] and D. Israel*

### *Summary*

In the Philippines, tilapia is the second most important fish species that is farmed to improve food security and alleviate poverty. Tilapia farming in the country dates back in the early 1950s with the introduction of the Mozambique tilapia. However, it was not until 1970s when Nile tilapia (*Oreochromis niloticus*) from Thailand and Israel was introduced into the country did the tilapia farming industry start to develop. With the introduction of better growing species, tilapia farming operations expanded and this resulted in improvement of the country's overall tilapia production. Along with this however was a problem which later emerged due to deterioration of genetic quality of farmed tilapia stocks. Farmers experienced decline in tilapia production; hence this prompted the national, regional and international organizations to develop new improved strains of the species and associated technologies.

The availability of improved Nile tilapia strains is a major factor that has opened up new avenues for renewed growth in the tilapia industry especially in the rural sector. This was hailed as a positive development in the tilapia industry because it promised opportunities for improvement of the rural economy. However, there are also challenges that need to be addressed.

This paper discusses the developments of tilapia aquaculture in the Philippines, the challenges in relation to the country's rural development and research needs.

### *Section 1: The Past*

1. Tilapia Aquaculture in the Philippines

<u>Tilapia and importance to Rural Development</u>

Combating poverty, particularly in the rural sector is a serious challenge of the Philippine Government. World Bank reported that in 2003 about 11 percent of Filipinos lived on less than US$1 per day and 40 percent on less than US$2 per day (Anon. 2006). The problem is most acute and widespread in the country's rural areas where the incidence of poverty is 54% compared to 25% in urban areas (United Nations 2005).

To address the above challenge, the country's Medium Term Philippine Development Plan (MTPDP) for 2004-2010 has identified the aquaculture sub-sector as one of those that will support the country's drive towards combating poverty and development of rural economy (ADB 2005). In line with this, the Philippine Department of Agriculture has formulated measures to achieve the desired growth in the agriculture and fisheries sectors. One of these is through farming of high priority species which include the Nile tilapia – a commodity which ranked second most important food fish for the country's mass domestic consumption (BFAR 2003).

<u>History and Production trends</u>

Tilapia farming in the Philippines began in 1950s and mainly utilized low-input backyard ponds using Mozambique tilapia (Oreochromis mossambicus) as cultured species. This species which was introduced into the Philippines in 1950s was unpopular because of its slow growth, small size at harvest, precocious breeding and other undesirable traits. In view of these characteristics, production of tilapias during 1960s was relatively low and ranged from 70-390 mt. (Figure 1)

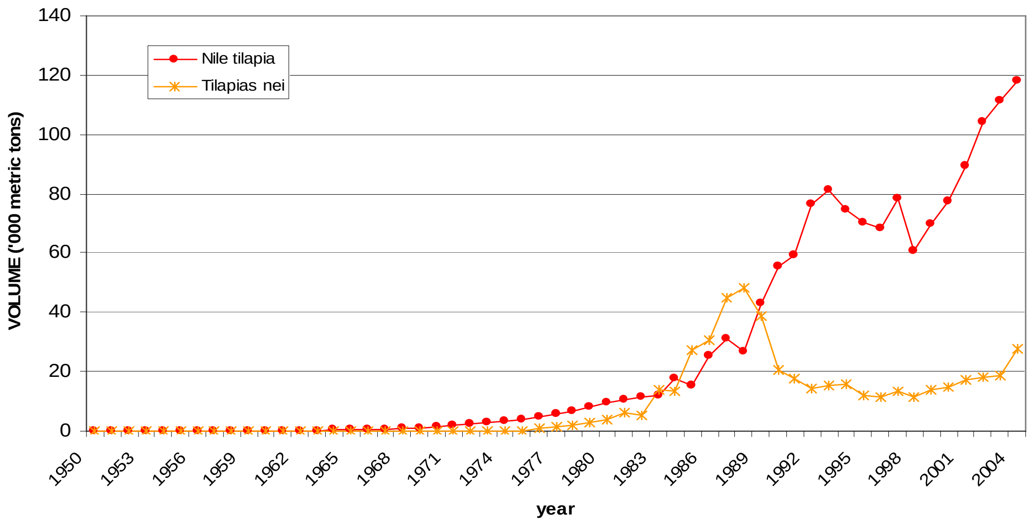


Figure 1.Total tilapia aquaculture production (volume = '000mt) in Philippines from 1950 – 2004 (FAO 2006)

In 1970s, a much faster growing tilapia species (Nile tilapia) was introduced into the country and this generated a renewed interest in tilapia farming. Subsequent to this was the development and successful application of culture technologies which resulted in widespread farming operation of tilapia (particularly in Luzon part of the Philippines) and subsequent growth in the country's overall production. Tilapia aquaculture production rose from 70-390 mt in 1960s to 9,436 – 15, 434 mt in 1980s. However, growth in overall tilapia production nearly disrupted during the 1980s when farmers experienced decline in farm productivity due to deteriorating quality of Nile tilapia stocks. To avert this problem and to address the emerging need of the tilapia industry, public sector R&D (government owned, regional and international) institutions pursued genetic improvement of locally farmed stocks through selective breeding (and other genetic improvement technologies) from 1986 to the present.

Dissemination of genetically improved Nile tilapia strains began in early 1990s and this signaled the start of a flourishing tilapia industry in the country. Figure 1 shows the year 1998-2004 as the period when there was accelerated growth in tilapia aquaculture and production reached its peak. With this 'boost' in production, the country emerged as the 3rd largest tilapia producer globally in 2004 (FAO 2006). The total tilapia production during this period was 145,869 mt, a substantial change from the production during the early years of tilapia industry when it was constrained by poor genetic quality of stocks and limited supply of tilapia seed.

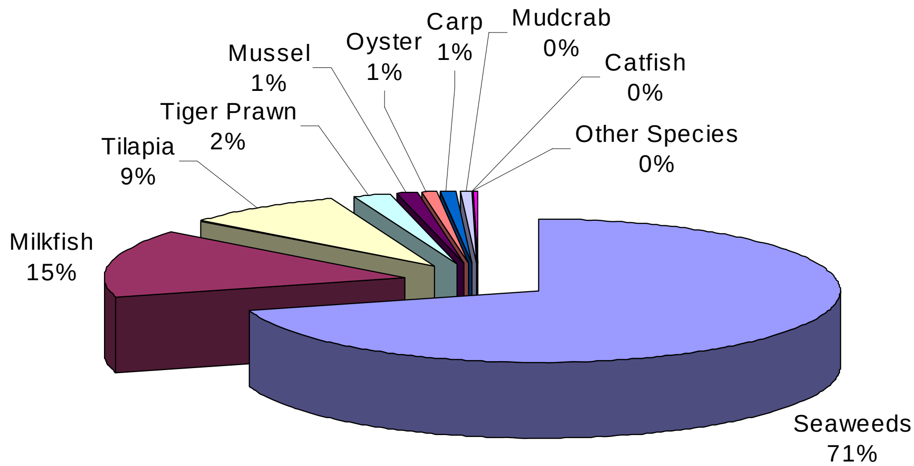


Figure 2. Aquaculture production in the Philippines by species in 2005 (Source: BAS, 2007)

In 2005, tilapia aquaculture production increased further (163,000mt) and contributed 9.5% to Philippine aquaculture production (BAS 2007). In terms of production by commodity, tilapia ranked third to seaweeds at 1,895,800 mt and milkfish at 289,200 mt (Figure 2).

2. Elements that made tilapia aquaculture in the Philippines reach the current level

The following have contributed to the growth of tilapia industry in the country:

Availability of a wide variety of improved tilapia strains. The development of improved tilapia strains is a major factor that spurred the growth of the tilapia industry in the Philippines. At present, the following improved strains of tilapia are available for farmers to choose from: GIFT (genetically improved farmed tilapia); GST (Genomar Supreme Tilapia), FaST (FAC Selected strain of tilapia), GET-EXCEL, GMT (genetically male tilapia), SEAFDEC selected strain. With the availability of improved strains and the opportunities for a better profitable margin, more and more farmers have become convinced to get into tilapia farming operations - both hatchery and grow-out. ADB (2006) reported that farmed tilapia production increased during the period 1981-2001 and this was mainly due to improved quality of seed available in the market

- Commitment of public sector institutions in tilapia R&D. One of the strengths of tilapia aquaculture in the country is the presence of public R&D institutions that are continuously committed to addressing the needs of the tilapia industry. It is a known fact the culture technologies and improved strains that are commercially available in the country are products of strong research and development cooperation of the public sector R&D institutions in the Philippines (national program institutions, regional and international research organizations based in the Philippines). Annex 1 discusses chronologically the initiatives which led to development of the improved strains. For over 20 years, these institutions have been actively involved in tilapia R&D and the Philippine tilapia industry has benefited immensely from the efforts made by these institutions/organizations (Abella 2006).

- Multi-stakeholder involvement in tilapia farming. The country's tilapia industry comprises various 'players' whose roles are crucial in the attainment of the goal as specified in the country's Master Plan for the Tilapia Industry (i.e., to increase the farmed tilapia production from 122,000 mt in 2002 to 250,000 mt in 2010). Recognizing the need for concerted efforts in order to meet this target, representatives of various stakeholder groups from the tilapia industry (R&D institutions, private sector, policy making bodies, feed manufacturers/suppliers, exporters, and farmers) have joined hands and in 2003, established the Philippine Tilapia Inc. This group provides a forum for stakeholders in the tilapia industry to work together through advocacy, promotion of tilapia consumption and implementation of the tilapia industry development plan (ADB 2005).
- Strong participation of the private sector. Another notable development which has provided a big boost in tilapia farming from latter part of 1990s to the present is the strong participation of the private sector, particularly in seed production. About 90% of the country's current tilapia seed production which amounts to 1 billion annually comes from the private sources. Apart from this, private sector farmers work hand in hand with the public sector in seed distribution, extension, financing for farm operations and setting directions for the tilapia sector (ADB 2005). Private seed and feed supplies advise farmers on appropriate practices as well as in improving their products and these have helped contribute to the rapid growth of the tilapia sector (Engle 2006).
- Government's support in tilapia industry. In view of the tremendous potential that tilapia could bring in terms of addressing the country's need to enhance food security, the Philippine Government strongly supports and widely promotes the nationwide farming of tilapia, particularly the genetically improved strain. In line with this initiative, the aquaculture sector through the government's agency – BFAR, provides a greater focus on developing an improved strain (GET-EXCEL) and making this and associated culture techniques available to farmers from all regions in the Philippines, through its dissemination programs..
- Strong market demand. The continuous improvement of tilapias by the public sector breeding institutions in the quality (e.g. improvement in size, carcass quality, etc.) has contributed to the increased demand for tilapia products in the market. Survey studies found that tilapia has become an important fish in the diet of Filipinos with decline in consumption of milkfish and round scad and other native freshwater fish (Edwards, 2006). Milkfish traditionally has been the most popular and widely farmed fresh and brackishwater fish in the country; and round scad traditionally has been the most popular and affordable marine fish for the poor.

## *Section 2: The future*

### 3. Challenges Facing Tilapia Farming

It is projected that by 2010, the Philippine population will reach 95 million and the expected demand for fish is 2.9 million mt. In view of this, the government is faced with a greater challenge of addressing the issue of food security, particularly in terms of sustainability of fish supply. By 2025, the demand for fish in the Philippines is expected to increase to about 4.2 million mt while the estimated population is 134.9 million (Anon. 2005).

Sustaining the growth of the country's tilapia production. The country's tilapia industry master plan has targeted a 72% increase in tilapia yield by 2010. In order to achieve this, it is imperative that growth of tilapia production is sustained and its full potential is harnessed in order to bring benefits to the rural economy and to the country in general. The Department of Agriculture (2002) reported that with the availability of improved tilapia breeds, existing science-based, farm-verified technologies for tilapia seed production and culture, this projected increase could be attained and sustained especially if the following concerns are addressed:

- maintenance of genetic integrity in improved tilapia stocks;
- sustainable production of genetically improved seedstock;
- formulation of guidelines on how to manage this new diversity (new genetically differentiated aquaculture stocks) in the context of resource conservation for aquaculture and fisheries;
- adoption of regulatory mechanisms for controlling environmental degradation caused by aquaculture activities in lakes, rivers and reservoirs where tilapia are farmed; and
- creation of a coordinating body composed of public and private sector representatives that will manage and ensure the growth of the tilapia industry (note: Philippine Tilapia Inc. was established in 2003 to address this need, see section 1, item 2 of this; the challenge now is how to sustain the interest of this coordinating body).

Bringing benefits of tilapia farming to the rural community. Apart from sustaining the country's growth of tilapia production, another big challenge for the Philippine Government is to ensure that the rural community will benefit from the tilapia industry. This is possible if the following are also addressed:

Making the improved strains and associated culture technologies available to rural sector. Enhancing the access of fish farmers (especially those from rural areas, operating in small-scale and with limited resources) to improved strains of tilapia is a challenge in the expanding tilapia industry. At present, most small-scale farmers are dependent on distribution centres for improved tilapia seeds that are expensive and not sufficient to meet market demands (Basiao et al 2005). Other farmers get their tilapia seed from suppliers who also act as middlemen and which, in many cases, result in higher price thus making the tilapia seed not affordable to farmers with limited capital.

Another factor which influences the accessibility of farmers is the geographical location. While the present government program undertakes widespread dissemination in all regions/provinces for GET-EXCEL, dissemination of most improved strains in the country is still largely confined in Luzon, the region in the Philippines where most tilapia producers are located.

Improving the access of rural sector farmers to financial resources. One of the serious constraints of farmers in getting into tilapia farming is their lack of capital/financial resources (Sevilleja 2006). Since the capital required to operate the tilapia farming is beyond the reach of ordinary small-scale farmers, the need to formulate mechanism for financial assistance so that farmers with limited resources, especially those from the rural sector can get into tilapia farming (hatchery or grow-out) is crucial. ADB (2005) reported that the Philippine government has low interest credit and financing programs for fisheries sector; however, these have been channeled through commercial private and government controlled financial institutions. Very few farmers avail these programs due to stringent requirements during application.

Enhancing the efficiency of extension system. The Philippine tilapia industry in general is still hampered by the lack of effective extension system. Despite the present efforts being made by the government in extending technical assistance to farmers, there is in general poor coordination among research institutions, local government units and farmers and this negatively affects the growth of the industry. It was also found that while private sector's involvement in dissemination of tilapia seed can help provide the link that will facilitate the transfer of improved strain and associated culture techniques to end-users, there are also issues that influence the efficiency and effectivity in delivery of these to small-scale farmers (Acosta et al 2006). There is a need to strengthen institutional linkages/stakeholder involvement for efficiency of extension services and for greater impact of tilapia farming to rural development.

Harnessing the full commercialization of tilapia. One of the weaknesses of the Philippine tilapia industry is the lack of strategy and supportive environment for full commercialization of tilapia, particularly in the export market. While the country performs well in terms of tilapia production (i.e. it consistently ranks as one of the top 10 producing countries globally), there are factors that impede the full commercialization of this commodity. The problem is more evident for small-scale producers in the rural community who, usually, do not have the capacity to comply with the regulations and standards set by the export market. Dey and Ahmed (2005) indicated that food safety regulations, hazard analysis and critical control point (HACCP) processes, and technical barriers to trade have introduced high costs that tend to exclude the small producers and processors from the export supply chain. Apart from these, there is also lack of market information and increased competition in sales which, in many cases, result in lesser income or profit on the part of these producers.

Dey and Paraguas (2001) reported that although tilapia is one of the cheapest fish in the Philippines, the price of tilapia in the Philippines is still higher than it is in international markets, making it difficult for the Filipinos to export the fish. In the Philippines, the high cost of commercial feed contributes largely to increase in the overall production cost of tilapia. Hence, another challenge is to bring down the production cost to enable the farmers to compete with the export market.

4. Research needs and lessons learned

R&D institutions have been major contributors to the country's ability to address the pressing issues affecting the tilapia aquaculture and as such have been credited as one of the prime drivers of growth in tilapia industry. It is crucial that these institutions remain vigilant to developments of the country's tilapia aquaculture sector and through research, training and extension continue to address the issues affecting the industry. Apart from this, complementary policy interventions must be identified and implemented to ensure that outputs of tilapia R&D will positively impact the rural economy and the country in general.

In view of the dynamics of tilapia industry in the Philippines, there is a need for both public and private sectors to continue working together in order to address the challenges mentioned in the preceding paragraphs and the targets indicated in the tilapia development plan. Specifically, the following research areas/initiatives are also suggested:

<u>Genetics</u>

Maintenance of the genetic integrity of improved tilapia stocks. Preliminary efforts have already been done (and should be continued) especially in monitoring the genetic integrity of farmed tilapia stocks (including genetically improved strains) using molecular markers and other methods.

Managing new genetically differentiated tilapia stocks. This can be done through marker-aided broodstock management schemes. With genetic marker data, appropriate broodstock management and genetic improvement methods can be formulated to protect the diversity of existing tilapia genetic resources. Thus whenever possible, DNA markers should be integrated in schemes that promote the sustainable management of farmed tilapias. Sustainable management can be achieved by both developing tilapia lines that can be utilized immediately for farming and maintaining highly genetic variable populations as valuable genetic resources for future use (Romana-Eguia and Taniguchi 2006).

Production

A study that will assess risk aspects of small-scale tilapia culture compared to other production-oriented investments. How should risk in tilapia culture in particular and aquaculture in general be minimized so the poor can truly practice it?

Marketing

Investigation on impact of middlemen, such as concessionaires, on the profitability and economic viability of small-scale tilapia farming, processing. This includes the search for ways to decrease the marketing chain for tilapia ventures in order the increase the profitability of culture.

Credit

Study of micro-credit and other mechanisms as a way of addressing the credit and finance-related aspects of small-scale tilapia culture.

Extension

Investigation on how the country's tilapia extension aspect can be improved. Why extension services are weak despite government/institutions' efforts. What are the factors that impede the effective delivery of extension services to farmers, particularly in the rural sector? Is there a need for improved extension scheme? Examples of current institutional efforts on this aspect are on-site training by BFAR, SEAFDEC AQD, and other local agencies; publication of tilapia extension manuals written in the vernacular.

Institutional

Role of cooperatives and farmer organizations in the conduct of small-scale tilapia culture. This includes a study on how small-scale tilapia growers and the poorest of the poor must be effectively organized to optimize access to production inputs, technology, credit, market opportunities (local and export) and other important components of a tilapia-based business operation.

Social

Socioeconomic survey of the potential specific areas and groups of poor population who can specifically be targeted for the development of tilapia culture. This also includes development of untapped areas for small-scale tilapia aquaculture (for example, lakes and other water bodies in Mindanao).

Nutrition

There is at present aggressive promotion by feed companies for the utilization of artificial feeds in fish farms especially in Luzon provinces. Commercial tilapia feeds are costly; hence, less and less farmers are able to use this for their farm operations. One important area of study for Philippines is to look for ways of lowering the production cost (includes the cost of inputs such as the tilapia feed).

Environment

Tilapia aquaculture is a dynamic and aggressive sector in the country. With the rapid expansion and intensification of tilapia farming in the country, it is crucial that an assessment be made on the environmental impacts of tilapia aquaculture and based on findings, identify and implement the policy interventions needed.

Lessons learned:

Much is expected from the Philippine tilapia aquaculture particularly in terms of addressing the country's food security agenda. There is no doubt that tilapia aquaculture will continue to grow in terms of production. However, the main challenge of the tilapia industry is how this growth can be sustained in the long-term and in a manner that all sectors of the society particularly the rural community will benefit from this.

In view of the high expectation from the tilapia aquaculture sector, the industry is now in a phase when cooperation and stronger partnerships among all the 'players' involved is crucial. The Philippine experience has revealed that if one is to address the needs of the tilapia industry, the programs of both the public and private sectors (particularly breeding and dissemination) must be in synergy or constantly in tune with the needs, requirements and capacities of the industry (Rodriguez 2006). Parallel efforts must also be made in formulation of policy programs and institutional mechanisms to ensure that benefits from tilapia farming and the advancements in tilapia technologies will reach the small-scale farmers and the rural community.

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Annex :

**Genetic Improvement Programs Undertaken in the Philippines**

A decade and a half after its introduction into the Philippines, growth of Nile tilapia stocks have deteriorated as a consequence of genetic founder and bottleneck effects (Pullin and Capili, 1988), gene introgression from the less desirable Mozambique tilapia (Macaranas et al, 1986) and inbreeding (Eknath et al, 1993). Because the tilapia genetic resources used for aquaculture then had been poorly managed, genetic improvement of these limited locally farmed stocks was pursued through selective breeding programs implemented in the Philippines from 1986 up to the present.

Quantitative genetics research on the Nile tilapia began in 1986 when SEAFDEC and Central Luzon State University (CLSU) became members of the Aquaculture Genetics Network in Asia (AGNA), a regional network supported by IDRC of Canada. Composed of five Asian countries (China, India, Indonesia, Philippines and Thailand), the network was organized (in coordination with IDRC consultants from Dalhousie University) to produce: (1) a group of aquaculture geneticists in Asia; (2) a set of proven techniques for aquaculture genetic data analysis and stock improvement; and (3) genetically improved strains of fish for use in Asia (Timm, 1988; Doyle and Newkirk, 1988). With support from IDRC, SEAFDEC and CLSU worked on tilapia genetic improvement by developing statistical and experimental procedures for genetic strain evaluation (Doyle et al 1990; Basiao and Doyle 1990a; Basiao and Doyle, 1990b; Romana-Eguia and Doyle, 1992; Eguia and Eguia, 1993; Eguia, 1996; Basiao et al 1996; Romana-Eguia and Eguia, 1999; Basiao, 2001), producing a salinity-tolerant strain of O. niloticus through hybrization with O mossambicus (Villegas, 1990; Basiao 2001) and enhancing growth in tilapia strains using within-family selection (Abella et al 1990; Bolivar and Newkirk, 2002). Apart from developing standard strain evaluation procedures at SEAFDEC, a fast-growing improved stock known as FaST or FAC-selected (Freshwater Aquaculture Center-selected) tilapia was developed by CLSU researchers . First introduced in 1993, this improved breed was produced through within-family selection involving locally adapted Asian Nile tilapia strains bred through a rotational mating scheme. The genetic gain per generation for this selected stock was estimated at 12% (Bolivar and Newkirk, 2002).

In 1988, two other internationally funded tilapia genetic improvement programs were implemented in the Philippines. In collaboration with BFAR, FAC-CLSU, UP-MSI and Institute for Aquaculture Research or AKVAFORSK of Norway, the World Fish Center (formerly ICLARM), conducted the Genetic Improvement of Farmed Tilapias (GIFT) project from 1988 to 1997 (Eknath et al 1993, Bentsen et al 1998; Gupta et al 2001). Funded by UNDP and ADB, the GIFT project developed the GIFT Tilapia, a synthetic strain produced by crossing the best families from four Asian and four African founder stocks. Growth of this synthetic breed was enhanced through several generations of combined selection. In 1999, the GIFT Foundation inked an exclusive contract with GenoMar ASA, a private multinational company, for the commercial rights and brand name of the GIFT Super Tilapia and subsequent improved breeds that may be derived from their joint research activities (Gjoen 2001). Presently, GenoMar has produced the GST or GenoMar Supreme Tilapia developed from the 9th generation GIFT (or G9) and further improved with the use of a DNA-based technology. Launched in late 2002, GST is believed to have 40% higher genetic gain (in terms of growth) compared to G9 (Gjoen 2001).

Simultaneous with the GIFT program, the GMIT (Genetic Manipulation of Improved Tilapia) or YY supermale project was implemented to principally address the problems of early sexual maturation, stunting and overpopulation in tilapia culture and also to generally solve genetic deterioration in farmed tilapia strains (Mair et al 1997). Conventional methods such as sex reversal, manual segregation of male tilapias from females and interspecific hybridization have been tried to solve overpopulation and stunting in farmed tilapias. This British ODA funded project allowed the University of Wales in Swansea, UK, FAC-CLSU and BFAR-NFFTRC to develop YY male tilapia genotypes (novel male tilapias with two male “YY” sex chromosomes instead of “XY” for normal males) through generations of feminization and progeny testing. When crossed with normal females, these YY supermales are able to sire a mean progeny sex ratio of 95% male (Mair et al 1997). Growth of GMT tilapia was shown to be 30-50% higher than mixed sex tilapia (Mair et al 1995; Camacho et al 2001).

In 1999, SEAFDEC developed its own growth-enhanced strain through a simple farm-based size-specific mass selection on previously size-graded stock. SEAFDEC-selected tilapia (SST) was developed from a domesticated Thai Nile tilapia stock called Chitralada. Response to selection after one generation of size-specific mass selection was noted at 3.2 % (Basiao and Doyle, 1999).

In 2002, BFAR introduced an improved tilapia stock known as “BFAR GET 2002 EXCEL Tilapia”. Dir Melchor Tayamen has coined the name “GET-EXCEL” which is an acronym for Genetically Enhanced Tilapia EXcellent strain that has Comparable advantage over other tilapia strains for Entrepreneurial Livelihood projects in support of aquaculture for rural development”. This stock was produced by combining strain crosses and adopting within family selection using the following strains: G8 or eighth generation GIFT, 13th generation FAST, Egypt and Kenya strains. The GET-EXCEL strain is purported to be 38% better in terms of growth and yield than unimproved tilapia stocks (Tayamen, 2005). This stock has been distributed by BFAR’s NFFTC, Central Hatcheries, Provincial/Municipal hatcheries and/or certified/registered private hatcheries to Philippine fishfarmers through the DA-initiated project entitled “Nationwide Dissemination of GET EXCEL Tilapia” (Tayamen, 2005). The project aimed to transfer genetically improved tilapia and updated rearing technologies to resource-poor farmers through -- breeding and production, training, evaluation, and seedstock distribution cum technology demonstration.

At present, several tilapia stocks have been developed for specific environments. To promote tilapia culture in brackishwater ponds, rivers and estuaries, PCAMRD, BFAR-NIFTDC and CIRAD of France, developed a highly saline tolerant tilapia referred to as Molobicus or SaltUNO. The selection scheme involved the repeated backcrossing of progenies of O niloticus and the hypersaline Oreochromis mossambicus (Camacho et al 2001; Rosario et al, 2005). Another salt-tolerant hybrid, BEST or Brackishwater Enhanced Selected Tilapia was developed by BFAR-NFFTRC and FAC-CLSU. This strain was developed using three euryhaline tilapia species (O mossambicus, O aureus and O spilurus) and three genetically improved Nile tilapia strains (GIFT, YY-supermale or GMT and FAST) as founder stocks. Meanwhile, to encourage tilapia culture in the Philippine uplands or in rural areas with relatively cooler climates, a cold-tolerant Nile tilapia stock named COLD was developed by BFAR-NFFTRC using the G8 or eighth generation GIFT and the FAST. Experimental trials have been made however the stocks have yet to be tested commercially.

The availability of these genetically enhanced stocks somehow contributed to improved yields particularly in the tilapia-producing provinces (Bulacan, Pampanga and Tarlac) near the Tilapia Science Center, Nueva Ecija, Philippines where most of these strains were developed and disseminated. Moreover, with the promotion and adoption of technologies for rearing salt-tolerant Nile tilapia strains, tilapia production from marine/brackishwater culture areas (especially in Visayas and Mindanao), have also gradually improved.

**This document includes reviews from three countries (Nepal, Sri Lanka and Pakistan) in which aquaculture is developed to a lesser extent than many others in the Asia-Pacific region. The reviews tend to highlight the current status and the constraints to aquaculture development and show case the instances where it had been successful.**

# Nepal

*Gagan BN. Pradhan*

Abbreviations

| | | |
|---|---|---|
| ADB | - | Asian Development Bank |
| ASC | - | Agriculture Service Center |
| DADO | - | District Agriculture Development Office |
| DOA | - | Department of Agriculture |
| DOFD | - | Directorate of Fisheries Development |
| FDC | - | Fisheries Development Centre |
| FRD | - | Fisheries Research Division |
| FRC | - | Fisheries Research Centre |
| FAO | - | Food and Agriculture Organization |
| GDP | - | Gross Domestic Production |
| HMG | - | His Majesty's Government |
| IDRC | - | International Development Research Center |
| MOAC | - | Ministry of Agriculture and Cooperatives |
| NARC | - | Nepal Agriculture Research Council |
| UNDP | - | United Nation Development Programme |

Tables

### ***Background***

Aquaculture is fairly a recent development endeavor in Nepal. It was initiated on a small scale with pond culture of indigenous major carp in the mid 1940s. Further development took place in the 1950s with the pond breeding success of exotic species; common carp followed monoculture practices of pond fish production in the country. More significant progress was seen in the 1970s with the successful hatchery breeding of three exotic Chinese carp species: silver carp, bighead carp and grass carp, and three commercially valuable indigenous major carps: rohu, mrigal and catla had been a major breakthrough in the development of aquaculture in Nepal. This followed  polyculture system of fish production in ponds with seven species of fish with different feeding habits. This practice contributed considerably to increased production per unit area and higher economic benefits, which in turn attracted a large number of farmers. The actual development of the practice was seen from the beginning of the 1980s with the execution of the Aquaculture Development Project supported by the Asian Development Bank (ADB) and the United Nations Development Programme (UNDP). Over the years, pond aquaculture has developed as the most viable and popular aquaculture production system in Nepal and accounted for over 90% of the total production of 20 000 tonnes in 2003/2004. The major part of the pond fish production takes place in the southern part of the country –the Terai plain where 94% of the fish ponds are located.

The cage fish culture and enclosure fish culture in lakes and reservoirs with herbivorous carps (major species: silver carp and bighead carp) was initiated with the support of FAO/UNDP and later the International Development Research Center (IDRC) Canada in the 1970s. The system has been quite successful in terms of utilizing natural productivity of the water bodies in fish production. The rice-fish culture practice in the hills and valleys was introduced in the 1960s in Nepal. In spite of its potential, this practice has not taken off. However, with the application of improved management techniques and careful planning this could be expanded significantly in the future. The fish culture in gholes - marginal agricultural irrigated areas, ditches, flood plains, swamps is a recent development intervention in Nepal. The practice has been quite encouraging as a poverty focused and livelihood improving activity for the targeted rural communities. The system also helps in promoting ecology of the water bodies. However, the system needs to be properly addressed and expanded as sustainable activity in the country. The culture of high-value cold water species, in particular Rainbow trout (Oncorhynchus mykiss), has been an on-going activity for some years. Its technical feasibility has been demonstrated at the farmers' field, and the activities have been developed for its expansion towards commercial scale production. Aquarium decoration is becoming a popular hobby in the urban community in Nepal. There is   market potential for its expansion in the country. The diverse nature of the river systems in Nepal provide potential sites for sports fishing for recreation and ecotourism promotion. Initiating activities have been already developed to this regard with positive indications for expansion.

The fisheries sector including aquaculture and capture fisheries contributed a total production of 42,463 metric tons of  fish valued Nepalese Rupees (NRs.) 4755 million (US $ 67 million) and contributed over 2% in the gross domestic production – Agriculture during 2004/2005 in Nepal. The fish seed industry is one of the important production areas in the aquaculture sector. It has been estimated (DOFD,2005) that a total of 8.56 million fish seed had been produced in 2004/2005 out of which 73 % had been contributed by the private sector in the country. The per capita fish production in Nepal reached 1676 g/year. A compilation estimated that fisheries and aquaculture development activities employed about 506,000 individual of 137,000 families and benefited 747,000 people (over 3% of the population) during 2004/2005 in Nepal. It has been estimated that aquaculture employed about 81,000 people and benefited about 169,000 people in 2004/2005. A preliminary analysis on employment and income generation has shown that aquaculture employed less member but with higher income potential compared to capture fisheries

The aquaculture development activities n Nepal are primarily governed by government policies. The current fisheries development policy objectives include: increased production through intensified, commercialized and diversified operations, appropriate management and conservation of indigenous fish species, and an improved marketing network for fresh fish by using appropriate post-harvest techniques. Aquaculture development has followed an encouraging path in Nepal. However, issues such as production systems and technologies, target group, input supply, extension support services, credit service, legal issues, environmental considerations, marketing service, institutional framework need to be properly addressed in order to achieve long-term sustainable goals.

Aquaculture development has come along an encouraging path in Nepal. However, there are issues which needed proper addressing for achieving long-term sustainable goals. These issues included: production areas and target groups; technology interventions on production and productivity issues; water supply systems and management; fish seed supply and management; other production input supply and management; extension support services and delivery systems; training services and delivery; credit services and systems; socio-cultural consequences and legalities; legal consequences and environmental considerations; marketing services and systems; institutional framework and mechanism; etc.

### *Water Resources*

Nepal is endowed with vast inland water resources in the form of rivers, lakes, reservoirs, ponds etc.. There are three major river systems: Kosi in the east, Gandaki in the central and Karnali in the west of the country. These rivers are fed by hundreds of small rivers originating in the high glacial Himalayan, Mahabharat and Siwalik mountain regions, and cover an estimated area of about 395,000 hectares. There existed a number of small to medium sized lakes in different parts of the country that cover about 5,000 hectares of surface area. In the same way, about 1,500 hectares of small reservoirs have been constructed in the country. In addition, a considerable water surface area of around 6,500 hectares of fish ponds are situated in various parts of the country. There are also an estimated area of about 12,500 hectares of marginal swamps found in the country, while irrigated paddy fields cover about 398,000 hectares in Nepal (DOFD, 2005)

Moreover, the growth of hydro-power interventions and irrigation infrastructures is likely to add more water bodies in the years to come. A feasibility study on various river basins and systems indicates an addition of about 78.000 hectares of fresh water reservoirs will be constructed upon their completion in the nation (DOFD, 2005).

Collectively, all these water bodies cover nearly 3 % of country's land area. It is estimated that some 500,000 hectares of water surface may be available for fish production, of which approximately 100,000 ha would be lakes, reservoirs and fish ponds. The existing water resources and their future potential reveal that there is tremendous scope for expansion and intensification of fish production in the country (Table 1).

Table 1. Estimated Water Surface Area in Nepal (DOFD,2005)

| Resource Details | Estimated Area (Ha,) | Coverage Percent | Future Potential Area (Ha,) |
|---|---|---|---|
| Natural Waters | 401,500 | 48.8 | - |
| Rivers | 395,000 | 48 | - |
| Lakes | 5,000 | 0.60 | - |
| Reservoirs | 1,500 | 0.20 | 78,000 |
| Village ponds | 6,500 | 0.80 | 14,000 |
| Marginal swamps around | | | |
| Irrigated fields | 12,500 | 1.40 | - |
| Irrigated paddy fields | 398,00 | 49 | - |
| Total: | 818,500 | 100 | |

### *Fish Consumption Patterns*

Fish is acceptable to all non-vegetarian population in Nepal. Culturally, fish is considered to be auspicious by the Nepalese people. Despite its auspicious character and significant dietary contribution, the per capita consumption of fish is rather low. The reason for this is that fish production in Nepal is restricted to inland capture fisheries and aquaculture because of country's landlocked nature. Likewise, imports are limited considering the poor purchasing power of the people, fish is relatively an expensive commodity in the country. However, fisheries development in Nepal represents a largely untapped resource with regard to land areas for increased production and by improved technology and management.

Most consumers preferred fresh fish in Nepal. Traditional smoking and drying methods in the rural areas are practiced with fish catch from the natural water bodies. The market for such product is limited to cultural purpose amongst specific segment of population only. The import of processed fish and fishery product is limited to affluent segment of urban population in Nepal. Likewise, fish catch from the natural waters is one of the main sources of animal protein amongst deprived targeted fishing community in the rural Nepal.

Fish consumption statistics on fish eating non-vegetarian segment of population has not been assessed so far in the country. However, the per capita fish consumption figures in Nepal are calculated simply dividing national fish production by country's total population. The per capita fish production figures recorded in 1981/82 was 330 g during the first year of the Asian Development Bank and UNDP supported project in Nepal. The per capita production of fish reached 783 g during last year of the Bank supported project in 1992/93 (Table 2). This significant increase in per capita fish production of over 2 folds during the project period had clearly indicated the popularity and expansion of aquaculture activities in the country. Over the years, the aquaculture production activities had been executed as regular government programme with steady pace and significant growth rate. The per capita production of fish had been recorded to be 1543 g in 2002/2003 during the first year of the Tenth Five Year Plan in the country. An official compilation revealed that the per capita fish production in Nepal reached 1676g in 2004/2005. The production figure has been estimated to reach 1868 g at the end of the Tenth Plan in 2006/2007 (Table 2.). The recent political changes in the country lead to redirecting many government priorities and programmes. The Government of Nepal is launching a Three Year Interim Plan 2007/2008-2010/2011. The per capita fish production figure has been estimated to reach over 2000 g by the end of Interim Plan period during 2010/2011 in Nepal.

### ***Fisheries and aquaculture in relation to the GDP, and the past trends in this regard***

The value of fish as a supply of high quality protein has further emphasised its important role in the food security of the country. In 2004/2005 the value of total fish production(42,463 tonnes) was estimated at Nepalese Rupees 4,755 million (US$ 67 million) and contributed over 2% in Gross Domestic Production (GDP) – Agriculture in current prices. The contribution of fisheries in the agriculture share of the Gross Domestic Production in 1992/93 during the last year ADB supported had been estimated to be over 1 % only. The growth trend concerning share of fisheries in the Gross Domestic Production – Agriculture remained to be significant and positive during the current Tenth Five Year Plan in Nepal (Table 2)

A strategy to reduce poverty is the main guiding criterion in the execution of the 10th Five Year Plan in the country. So the fisheries sub-sector programme is also focussed on creating livelihood opportunities for the targeted rural population in order to promote poverty alleviation. Fish culture in gholes has been specifically developed to use these resources by involving rural targeted communities more so as to improve their livelihood and assist poverty alleviation. Cage fish culture and enclosure fish culture are also rural targeted community based programmes and contribute significantly to poverty alleviation. Programmes have recently been developed to involve small-scale rural targeted communities in fish seed nursing activities as additional livelihood opportunities. While in the overall aquaculture development trend, pond aquaculture seems to have emerged as the as the most viable and popular activity in terms of employment, production and area covered in the country. All these aquaculture production activities have contributed to the overall economic development of the country and continued to do more in future with all their potential in the country.

According to a country profile of Nepal (Directorate of Fisheries Development, 2005) it has been estimated that during 2004/2005 aquaculture and allied activities employed 79,000 individuals including 55,000 male and 26,000 female members of 31,000 families and benefited 169,000 people in the country. At the same time capture fisheries production in Nepal employed about 425,000 people including 171,000 male and 254,000 female members in 2004/2005 The fisheries sub sector including aquaculture benefited 747,000 people about 3% of the total national population in 2004/2005. The sub sector employed 506,000 individuals including 226,000 male and 280,000 female members of 137,000 families during 2004/2005 in Nepal (Table 3). A preliminary analysis on employment and income generation revealed less member of employment in aquaculture with higher income potential. The number of females involved in aquaculture and associated activities has been estimated to be less than half. Their involvement in capture fisheries has been estimated to be about 60%. A preliminary analysis of those who benefit from this sector has revealed that it is about 3% of the total population.

In 2004/2005 this sub sector also employed an estimated number of 9 000 families, with about 21 000 individuals actively involved in associated activities such as seasonal workers (e.g., fish harvesting, processing, earthwork,) and support services (e.g., marketing, storage, transportation, research, education, public sector institutions). The involvement of community-based organizations and non-governmental organizations in legal matters, capacity building, support services and delivery in the sector is an increasing trend and has to be assessed accordingly.

### *Aquaculture Production trends in relation to environment cultured, commodities, and current predictions*

The aquaculture production programme in Nepal began in 1981/82 with the execution of the Aquaculture Development Project supported by the Asian Development Bank and the United Nations Development Programme. In 1981/1982 aquaculture production was estimated to be 750 tones. It reached 8 317 tones in 1992/93. This increase in production of over 11 times within 11 years of the project period was the remarkable accomplishment of the growth of the industry in the country. Aquaculture production continued to increase significantly upon termination of the project and reached 17,640 tones in 2002/2003 during the first year of the current Tenth Five Year Plan. From the overall development of aquaculture production trends, pond fish culture was developed into one of the major production systems and contributed 20,213 tones of fish in the total aquaculture production of 22,480 tones accounting for over 90% of production and area coverage during 2004/2005 in the country. The pond aquaculture has been estimated to contribute about 90% production share during the last year of the Tenth Five Year Plan in 2006/07 with a growth rate of over 53% in production and area expansion by over 9 % against the base year 2001/2002 (Table 4A ). The pond aquaculture has been projected to contribute a major share in area coverage and production during Three Year Interim Plan (2007/08 – 2009/10) too. It has been estimated that pond aquaculture would contribute 29,145 tones of in the total aquaculture production of 35,230 tones by the last year of Interim Plan Period during 2009/2010 in Nepal.(Table 4B.)

An official compilation for 2004/2005 indicates pond aquaculture of carps has emerged as a popular activity in the eastern and central Terai, or more so than in the other parts of the country. About 94% of the total ponds of the country are found in the Terai, providing over 98 % of the total production from pond fish culture. The Eastern Development Region represents about 40 % of ponds and produces 35 % of total fish production from pond culture of carps. While the Central Development Region represents about 40 % of total pond fish production and Western Development represents with a highest average pond fish yield of 3.48 tones/ha. in the country (Table 5 A)

The contribution of cage fish culture, enclosure fish culture and rice fish culture in terms of area coverage and production remained to be nominal with consistent and steady growth pattern. Over the years, the contribution of extensive fish culture in gholes – marginal agriculture swamps looked to be significant in terms of expansion and production in the overall aquaculture development and continued to be so in future too.(Table 5B). A data compilation for 2004/2005 revealed that the cage fish culture and enclosure fish culture has been confined to hilly region of the country. Likewise, rice cum fish culture occupied major areas in the hilly areas compared to Terai. While, Fish culture in gholes occupied major areas in the Terai with very little area covered in the hills (Table.5B)

The intensive culture of exotic cold water species Rainbow trout has been projected to contribute a considerable quantity of about 2,000 tones in the total aquaculture production during the last year of the Interim Plan in 2009/10. The culture of Rainbow trout is a new developmental intervention in the aquaculture sector proposed to be executed during Three Year Interim Plan Period in the country.(Table 4B) . The culture of Rainbow trout has been projected to expand along the potential cold water corridors in the hills and mid hills around outskirts of urban areas.

A compilation (FAO, 2005 and DOFD, 2005) indicated that in 2004/2005 silver carp accounted for the major share of (6,77 tones, 30 %) of total aquaculture production of 22,480 tones (Table

6A). However its price was reported to be the lowest among other cultured species.The production share of silver carp was reported to be high in all production systems. Common carp is a popular fish after silver carp, and fetches a higher price than silver carp. The cyprinids – three indigenous major carps (L. rohita, C. mrigala  and C. catla) make up a significant share of the total aquaculture production in the country. These species are popular as a delicacy compared to other cultured exotic carps and accordingly fetch much higher prices (Table 6B.).

.The fish seed industry is one of the important production areas in the aquaculture sector. It has been estimated (DOFD, 2005) that a total of 8.56 million fish seed were produced in 2004/2005, of which 73% were provided by the private sector in the country. The Total fish seed production has been projected to reach 9.41 million with 74 % share of private sector in 2006/2007 during the last year of the Tenth Plan in the country  (Table 7A). Likewise, common carp and silver carp constituted major share in the total fish seed production in 2004/2005 in the country (Table 7B)

A number of freshwater indigenous fish species of economic value – Schizothorax spp, Tor spp., and Neolissocheilus hexagonolepis. and others such as Anguilla spp., Puntius spp., etc from capture fisheries are popular as a delicacy and fetch much higher prices than any other cultured species in the country. The total production of these indigenous fish has been estimated to be 19,983 tones in 2004/2005 (Table 6B)

An official data compilation on preliminary estimates of fishery and livestock production in 2004/2005 revealed fish production ranked second to total meat production in the country (Table 8)

### ***Major development programmes in relation to aquaculture undertaken over the last two decades***

The major aquaculture development programme in Nepal commenced in the early 1980's with the execution of the Aquaculture Development Project supported by the Asian Development Bank and the United Nations Development Programme. The project had contributed to the remarkable growth of aquaculture industry in terms of production and employment in Nepal. The traditional village ponds existed in Terai had been utilized for  pond fish culture and initiated its development accordingly. The project support towards strengthening of public sector facilities and capability building  had been quite instrumental  in quality input supply (fish seed) and effective support services delivery to the private sector which attracted increased number of farmers/entrepreneurs to take up pond fish culture in Terai as means of livelihood. Over the years, pond aquaculture have been developed as the most viable and popular aquaculture production systems in Nepal. It contributed about 90% in the total production of 22, 480 m tons during 2004/05 in the country (Table.4A). The major part of the pond fish farming take place in the southern part of the country – Terai plains where over 94 % of the ponds are situated which covered over 97% of the total pond water surface area in Nepal (Table5A.)

Further development programme in aquaculture sub sector had  been started in the late 1970s with the support of FAO/UNDP initiated integrated pond fish culture development programme in western Terai and cage fish culture of herbivorous carps (major species: silver carp and bighead carp) in the lakes of Pokhara Valley. The cage culture of carps was further expanded in the Indrasarobar reservoir later in the early 1980s with the support of the International Development Research Center (IDRC) Canada in the 1970s.

The cage fish culture system in these water bodies is basically to utilize natural productivity for fish production. The system had been quite popular and adopted with remarkable success in Nepal. Studies are also being carried out to examine the viability of intensive culture of common carp and rainbow trout with supplementary feeding in cages with environmental qualifications. Carp polyculture in lake enclosures has been developed as a popular aquaculture activity. Simultaneously, carp polyculture in lake enclosures had been developed as popular activity. It has further underlined the potential role of lakes for increasing fish production.. The cage fish culture contributed 216 tones of fish from 36 000 m3 of cages, with an average yield of about 6 kg/m3 of cages during 2004/2005 in Nepal. In the same way the production from fish culture in lake enclosures reached 130 tones from an area covering 100 ha during 2004/2005 (Table 4A)

The cage fish culture in the lakes of Pokhara valley had been focused to targeted and deprived fishing community as additional means of livelihood to support conservation management of natural fish stock and the aquatic ecosystems. While the cage fish culture in the Indrasarowar hydro-power reservoir was initiated as mitigation measures for the displaced and deprived fishing community. The community concept in managing cage fish culture activities as well as fisheries resources in these water bodies exhibited an exemplary in terms of institutional development and technical capability. The recent take over by a cooperatives composed of locals of diverse socio-economic stratum in managing the fisheries resources conservation and production of one of the lakes in the Pokhara valley had begun to show positive impacts.

Introduction of rice-fish culture during 1960s in the hills and valleys had been a significant aquaculture development intervention in Nepal. In spite of its potential, this practice has not taken off. With the application of improved management techniques and careful planning, this could be expanded significantly in the future. In 2004/2005 this practice contributed 87 tones from an area covering 218 ha. in the country (Table 4A)

Fish culture programme in the marginal agricultural land along irrigated areas, ditches, flood plains, swamps etc. has recently been developed to utilize these areas through increased participation of rural targeted communities in managing the resource for production. An extensive system of carp polyculture practice has been adopted in these areas. Fish production activities in such areas provide livelihood opportunities to the targeted local communities to aid poverty alleviation and help to promote ecology of the water bodies. There are about 12, 500 ha of such areas available in the country, of which approximately 1400 ha are currently being used for fish culture (Table 4A)

The intensive culture of high-value exotic cold water species Rainbow trout (Oncorhynchus mykiss) in race way ponds, has been an on-going activity for some years. Its technical feasibility has been demonstrated at the farmers' field, and the activity is being expanded for commercial scale production in the potential and accessible hilly areas of the country.

The diverse nature of the river systems in Nepal provide potential sites for sports fishing for recreation and ecotourism promotion. The importance of the enterprise has been realized at the policy level but has not been properly initiated so far. Ranching and open stocking of economically important cyprinids has been initiated in some of the snow fed rivers in the country, but the viability of this has not been yet assessed with a view to further expansion

Aquarium decoration is becoming a popular hobby in the urban community in Nepal. There may be a market potential for its expansion in the country and activities have been initiated accordingly in the country.

### *Current and changes in governmental policies in relation to aquaculture development*

The Fisheries sector's utility and contribution in terms of food security, poverty alleviation, livelihood, natural resources conservation and environmental management has been well recognized in Nepal. The sector has been provided due priority by the government for the speedy development of the sector in the country. Fisheries activities in Nepal are split by policy guidelines into inland aquaculture and natural water fisheries. Aquaculture involves all activities where complete or partial control of fish production cycle is undertaken. While natural water fisheries cover fish catch from natural water bodies where little (enhancement through open stocking, habitat improvements, etc) or no control measures are taken over the fish production cycle (capture fisheries).

The recent political change in the country had lead to redirecting many government priorities and policies. The fundamental aspects of 4R's: reconstruction, reestablishment, rehabilitation and reintegration have been identified as the major focus areas to be considered in every further interventions in the changed context. Essentially, the fisheries sector activities also are to follow this national fundamental directives in every development endeavors. In the mean time, the fisheries sector's development programmes are formulated and implemented in line with the long term fisheries perspective plan's ( FPP's) vision as well as the National Agriculture Policy 2061 and relevant plan and policy guidelines.

The current fisheries development policy objectives include: increased production through intensified, commercialized and diversified operations; appropriate management and conservation of indigenous fish species and aquatic ecosystems; creating livelihood opportunities to aid poverty alleviation; and improved marketing network for fresh fish by using appropriate post-harvest techniques.

In order to meet the goals envisaged in the policy objectives, the government planned to execute following programmes:

- production up scaling programme
  - through species diversification and intensive management techniques: intensive polyculture of carps: intensive polyculture of carps with tilapia; monosex culture of tilapia: intensive polycuculture of carps with *Macrobrachium:* Intesive *Macrobrachium* farming, controlled commercial *Clarias* farming
  - develop aquaculture production pockets into agro-economic zones as self contained commercial entriprises
  - expansion of potential high valued commodities on comparative advantages and specific geographic locations- exotic Rainbow trout along cold water corridors of the hills and mid-hills
  - concept of cluster farming techniques for expanding rice cum fish culture, and community concept in managing cage fish culture and enclosure fish culture in lakes and reservoir
- livelihood opportunities for targeted community to support poverty alleviation:

  fish culture in gholes, fish culture in road side ditches and depressions, and small scale farming systems (kitchen ponds),

- input supply and marketing management: supply of fish seed and fresh fish by developing organized competitive market network
- conservation management of of natural fisheries resources enforcement of acts and regulation to control illegal fishing, community concept in conservation management of fish biodiversity and aquatic ecosystems, capability build up and mass awareness, etc
- human resources development through capacity enhancement

Aquaculture development has followed an encouraging path in Nepal. However, issues such as production systems and technologies, target group, input supply, extension support services, credit service, legal issues, environmental considerations, marketing service, institutional framework need to be properly addressed in order to achieve long-term sustainable goals.

### *Major constraints to aquaculture development in the past and envisaged constraints*

Overall fisheries activities in the country are primarily governed by policy strategy laid down by the government. The Directorate of Fisheries Development of the Department of Agriculture, His Majesty's Government of Nepal, as the focal institution, formulates and executes national fisheries and aquaculture development plans and programmes endorsed by the Ministry of Agriculture and Cooperatives upon approval from the National Planning Commission of His Majesty's Government of Nepal.

Specific legislation on aquaculture production and development has not yet been formulated or enforced in the country. Entrepreneurs and the industry find this of utmost concern. Aquaculture production potential in the country and its market potential elsewhere in the context of the World Trade Organization (WTO) has further stressed the need for proper legislation and capacity building for the sustained growth of the sector.

The importance of and need for fisheries resource conservation was realised quite earlier in the country. The Aquatic Life Conservation Act 1961 – "JAL CHAR SANRAKSHAN AIN – 2017" had been adopted, but could not be executed for quite a time. In 1999 the Act was revised and amended (2055 BS). It included important aspects such as its scope and the definition of different terms specified in the Act. Other aspects included: restrictions on killing and capture methods, punishments, citizen's obligations, role and responsibility of local authority and technical authority, etc. concerning aquatic life and its conservation. However, the Act is not yet in operation, because laws and regulations are in the process of being approved by His Majesty's Government of Nepal.

There are specific limitations on further expanding the cage fish culture and enclosure fish culture and popular production systems. Similarly, rice-fish culture as an early intervention could not develop due to cross technological and input management problems. Fish culture in gholes was developed as a popular livelihood improving system for the rural targeted community and poverty focused production system. The production estimate (DOFD, 2005) from this culture was reported to be 20 tones in 1992/1993, reached 1 254 tones in 2002/2003 and 1 519 tones in 2003/2004. This tremendous increase in production clearly indicates the significant usefulness and popularity of the system. It should be properly assessed for its encouraging role in poverty alleviation and expanded as a sustainable activity in the country.

Moreover, the feasibility of high value cold water executed species – rainbow trout - has encouraged its commercial production in the country.

The practice of open water stocking of hatchery seed has been significant in increasing fish production and improving the livelihood of the fisher communities. With the use of proper gear and improved management, fish production can be further increased in the country. Aquarium decoration is becoming a popular hobby among the urban community of Nepal. There may be market potential for its expansion in the country. The diverse nature of the Nepalese river systems provides potential sites for sports fishing for recreation and tourism. Mahseer is a famous native game fish of Nepal together with asala, katle, gonch, etc. Preliminary attempts have been already initiated for further expansion in this regard.

The environmental impact of pond aquaculture is primarily limited to the conversion of paddy fields into fish ponds. Environmental pollution due to spillover, nutrient leaching or chemicals is not reported and banned chemicals are not used. The production activity is not intensive and heavy manure, fertilizer and supplementary feed are not applied in ponds, so problems of sedimentation and water quality deterioration are not faced. However, organic waste from the locality during monsoons is dumped into the ponds. This may sometimes cause deterioration in the water quality which again is not serious. Flooding, silting, and drought are observed. The physical destruction of ponds, heavy silting and a decline in water level in ponds due to these environmental problems sometimes cause heavy product losses. Massive deforestation in the lake and reservoir catchments area causes severe soil erosion and landslides during monsoons. The surface run-off water from these areas carries enormous amounts of silt and organic waste which drain into lakes and reservoirs. Problems with silting are particularly acute in Lakes Phewa and Rupa in the Pokhara valley and Kulekhani reservoir in Makwanpur. This may cause heavy production losses from cage/pen enclosure fish culture and open water stocking management activities undertaken in these water bodies.

Aquaculture development has followed an encouraging path in Nepal. However, issues such as production systems and technologies, target group, input supply, extension support services, credit service, legal issues, environmental considerations, marketing service, institutional framework need to be properly addressed in order to achieve long-term sustainable goals.

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Table 2: Details of Fish Production, Yield, per capita production and Gross Domestic Production from Aquaculture and Fisheries in Nepal

| Particulars | ADB Supported Project | | Base Year | With Five Year Plan | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Accomplishment | | | Projected | |
| | 1981/82 | 1992/93 | 2001/02 | 2002/03 | 2003/04 | 2004/05 | 2005/06 | **2006/07** |
| National Fish Production (mt.) | 3530 | 14728 | 35000 | 36568 | 39947 | 42463 | 45425 | 46751 |
| 1.1 Aquaculture | 750 | 8317 | 17100 | 17680 | 20000 | 22480 | 25409 | 26650 |
| 1.2 Capture Fisheries | 2780 | 6356 | 17900 | 18888 | 19947 | 19983 | 20016 | 20100 |
| Average Retailed Price of Fresh Fish (Rs.) | NA | 65.9 | 107.03 | 102.67 | 106.19 | 111.98 | 112.00 | 112.00 |
| National Average Pond Fish Yield (mt/ha) | 0.8 | 1.8 | 2.6 | 2.67 | 2.96 | 3.24 | 3.55 | 3.66 |
| National Population (No.) based on 2.25% annual growth rate | NA | NA | 23151 | 23670 | 24797 | 25343 | 25913 | 26496 |
| Per Capita Fish Production (g/yr) | 330 | 783 | 1512 | 1543 | 1611 | 1676 | 1753 | 1868 |
| Value of Fish Product (Rs. in million) | 247 | 974 | 3746 | 3754 | 4242 | 4755 | NA | NA |
| Gross Domestic Product-GDP (Agriculture) in current prices (Rs. in million) | NA | 70090 | 160141 | 171104 | 183357 | 193291 | NA | NA |
| Share of Agriculture in National GDP (%) | NA | 42.93 | 39.48 | 39.29 | 38.81 | 38.34 | NA | NA |
| Share of Aquaculture & Fisheries in Agriculture GDP (%) | NA | 1.4 | 2.3 | 2.2 | 2.3 | 2.46 | NA | NA |
| 9.1 Share of Aquaculture | NA | 0.79 | 1.12 | 1.06 | 1.15 | 1.3 | NA | NA |
| 9.2 Share of Fisheries | NA | 0.61 | 1.18 | 1.14 | 1.15 | 1.16 | NA | NA |

Note: NA= Not Available/ Not Applicable

Source: DOFD, HMG Nepal

Table 3: Estimates on Human Resources and Beneficiaries in Aquaculture and Fisheries Sector in Nepal (2004/2005 AD) (Figures in "000)

| Particulars | Base Year | With Five Year Plan | | | | | Percent (%) against in Base Year |
|---|---|---|---|---|---|---|---|
| | | Accomplishment | | | Projected | | |
| | 2001/02 | 2002/03 | 2003/04 | 2004/05 | 2005/06 | 2006/07 | |
| Employment (No.) | 469 | 485 | 504 | 506 | 513 | 514 | 10 |
| Male | 204 | 213 | 224 | 226 | 230 | 230 | 13 |
| Female | 265 | 272 | 280 | 280 | 283 | 284 | 7 |
| Aquaculture and allied activities | 76 | 76 | 79 | 81 | 86 | 86 | 13 |
| Male | 52 | 52 | 54 | 55 | 58 | 58 | 12 |
| Female | 24 | 24 | 25 | 26 | 28 | 28 | 17 |
| Capture fisheries | 393 | 409 | 425 | 425 | 427 | 428 | 9 |
| Male | 152 | 161 | 170 | 171 | 172 | 172 | 13 |
| Female | 241 | 248 | 255 | 254 | 255 | 256 | 6 |
| Total Family (No.) | 127 | 131 | 136 | 137 | 140 | 140 | 10 |
| Aquaculture and allied activities | 29 | 29 | 30 | 31 | 33 | 33 | 14 |
| Capture fisheries | 98 | 102 | 106 | 106 | 107 | 107 | 9 |
| Total Beneficiaries (No.) | 690 | 714 | 741 | 747 | 758 | 764 | 11 |
| Aquaculture and allied activities | 156 | 158 | 163 | 169 | 180 | 181 | 16 |
| Capture fisheries | 534 | 556 | 578 | 578 | 578 | 583 | 9 |
| Total Beneficiatires Proportion of the National Population | 3.0 | 3.0 | 3.0 | 3.0 | 3.1 | 3.1 | 3.4 |
| Aquaculture and allied activities | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 8.3 |
| Capture fisheries | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.4 | 1.9 |
| Average household size | 5.44 | 5.44 | 5.44 | 5.44 | 5.44 | 5.44 | 0 |
| National Population (No.) | 23151 | 23670 | 24797 | 24797 | 24797 | 24797 | 7 |

Table 4 (A): Details of Area Coverage and Fish Production from Aquaculture and Fisheries in Nepal

| Particulars | ADB Supported Project | | | | Base Year | | With Five Year Plan | | | | | | | | | | Growth % Compered the Base Year | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Accomplishment | | | | | | Projected | | | | | |
| | 1981/1983 | | 1992/1994 | | 2001/02 | | 2002/03 | | 2003/04 | | 2004/05 | | 2005/06 | | 2006/07 | | | |
| | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) | Area (ha) | Prod. (t) |
| Aquaculture | | 750 | | 8317 | | 17100 | | 17640 | | 20000 | | 22480 | | 25409 | | 26650 | | 56 |
| Pond Aquaculture | 944 | 740 | 4593 | 8215 | 5954 | 15516 | 5987 | 16000 | 6093 | 18060 | 6220 | 20213 | 6337 | 22545 | 6500 | 23800 | 9 | 53 |
| Paddy cum Fish culture | | | | 17 | 160 | 64 | 160 | 64 | 218 | 87 | 277 | 111 | 300 | 120 | 300 | 135 | 88 | 111 |
| Cage Fish culture (m3) | 3110 | 10 | 10639 | 56 | 30000 | 180 | 32000 | 192 | 34000 | 204 | 36000 | 216 | 80000 | 480 | 80000 | 480 | 167 | 167 |
| Pen/Enclosure Fish culture | | | 4 | 9 | 100 | 130 | 100 | 130 | 100 | 130 | 100 | 130 | 100 | 140 | 100 | 140 | 0 | 8 |
| Other Areas (Extensive fish culture in swamps and ditches) | | | 61 | 20 | 1000 | 1170 | 1072 | 1254 | 1225 | 1519 | 1400 | 1778 | 1612 | 2096 | 1612 | 2096 | 61 | 79 |
| Aquaculture Activities (Public Sector) | | | | 55 | | 40 | | 40 | | | | 32 | | 28 | | | | |
| Capture Fisheries | 728500 | 2780 | 728500 | 6356 | 811000 | 17900 | 810928 | 18888 | 810785 | 19947 | 810610 | 19983 | 810388 | 20016 | 810388 | 20100 | 0 | 12 |
| Rivers | 395000 | 2075 | 395000 | 3950 | 395000 | 5233 | 395000 | 6004 | 395000 | 6881 | 395000 | 6951 | 395000 | 6992 | 395000 | 7031 | 0 | 34 |
| Lakes | 5000 | 25 | 5000 | 139 | 5000 | 780 | 5000 | 780 | 5000 | 785 | 5000 | 795 | 5000 | 800 | 5000 | 805 | 0 | 3 |
| Reservoirs | 1500 | | 1500 | 77 | 1500 | 341 | 1500 | 350 | 1500 | 354 | 1500 | 356 | 1500 | 363 | 1500 | 364 | 0 | 7 |
| Other Areas (swamps and ditches) | 2000 | 100 | 12500 | 500 | 11500 | 5003 | 11428 | 5028 | 11285 | 5102 | 11110 | 5051 | 10888 | 4976 | 10888 | 4987 | -5 | 0 |
| Paddy Fields | 325000 | 580 | 325000 | 1690 | 398000 | 6543 | 398000 | 6726 | 398000 | 6825 | 398000 | 6830 | 398000 | 6885 | 398000 | 6913 | 0 | 6 |
| Total | | 740 | | 9960 | | 35000 | | 36568 | | 39947 | | 42463 | | 45425 | | 46750 | | 34 |

Source: DOFD, HMG Nepal

Table 4 (B): Details of Area Coverage and Fish Production from Aquaculture and Fisheries in Nepal During Interim Plan Period (2007/08 - 2009/010)

| **Particulars** | **Base Year** | | | | **Proposed 3 Year Interim Plan Period** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **2005/06** | | **2006/07** | | **2007/08** | | **2008/09** | | **2009/010** | |
| | **Area (ha)** | **Prod. (t)** | **Area (ha)** | **Prod. (t)** | **Area (ha)** | **Prod. (t)** | **Area (ha)** | **Prod. (t)** | **Area (ha)** | **Prod. (t)** |
| **Aquaculture** | | **25409** | | **26701** | | **29151** | | **31855** | | **35230** |
| Pond Aquaculture | 6337 | 22545 | 6500 | 23800 | 6842 | 25553 | 7150 | 27135 | 7500 | 29145 |
| Paddy cum Fish culture | 300 | 120 | 300 | 135 | 350 | 158 | 400 | 180 | 500 | 225 |
| Cage Fish culture (m3) | 80000 | 480 | 80000 | 480 | 85000 | 510 | 95000 | 570 | 10000 | 600 |
| Pen/Enclosure Fish culture | 100 | 140 | 100 | 140 | 100 | 140 | 100 | 140 | 100 | 140 |
| Other Areas (Extensive fish culture in swamps and ditches) | 1612 | 2096 | 1612 | 2096 | 1800 | 2340 | 2100 | 2730 | 2400 | 3120 |
| Trout Farming in Raceway ponds | | | 0.25 | 50 | 2.25 | 450 | 5.50 | 1100 | 10 | 2000 |
| Aquaculture Activities (Public sector) | | 28 | | | | | | | | |
| **Capture Fisheries** | **810388** | **20016** | **810388** | **20100** | **808388** | **21496** | **810388** | **21496** | **810388** | **21488** |
| Rivers | 395000 | 6992 | 395000 | 7031 | 395000 | 7110 | 395000 | 7110 | 395000 | 7110 |
| Lakes | 5000 | 800 | 5000 | 805 | 3000 | 850 | 5000 | 850 | 5000 | 850 |
| Reservoirs | 1500 | 363 | 1500 | 364 | 1500 | 384 | 1500 | 384 | 1500 | 384 |
| Other Areas (swamps and ditches) | 10888 | 4976 | 10888 | 4987 | 10888 | 5988 | 10888 | 5988 | 10888 | 5980 |
| Paddy Fields | 398000 | 6885 | 398000 | 6913 | 398000 | 7164 | 398000 | 7164 | 398000 | 7164 |
| **-** | | | | | | | | | | |
| **Total** | | **45425** | | **46801** | | **50647** | | **53351** | | **56718** |

Source: DOFD, HMG Nepal

**Table 5 (A). Pond Fish Culture in Different Geographical Locations of Development Regions in Nepal (2004/2005 AD)**

| Particulars | Development Regions | | | | | | |
|---|---|---|---|---|---|---|---|
| | Eastern | Central | Western | Mid-Western | Far-Westren | Total | Percent (%) |
| **Districts in the country** | | | | | | | |
| Mountains | 3 | 3 | 2 | 5 | 3 | 16 | 21 |
| Hills | 8 | 9 | 11 | 7 | 4 | 39 | 52 |
| Terai | 5 | 7 | 3 | 3 | 2 | 20 | 27 |
| Total | 16 | 19 | 16 | 15 | 9 | 75 | 100 |
| **Pond Fish Culture** | | | | | | | |
| **Programme executed districts** | | | | | | | |
| Mountains | 1 | 2 | 0 | 0 | 1 | 4 | 25 |
| Hills | 6 | 8 | 10 | 3 | 0 | 27 | 69 |
| Terai | 5 | 7 | 3 | 3 | 2 | 20 | 100 |
| Total | 12 | 17 | 13 | 6 | 3 | 51 | 68 |
| **Number of ponds** | | | | | | | |
| Mountains | 10 | 25 | 0 | 0 | 5 | 40 | 0.17 |
| Hills | 240 | 452 | 493 | 147 | 0 | 1332 | 5.80 |
| Terai | 8801 | 6457 | 3575 | 1580 | 1195 | 21608 | 94.03 |
| Total | 9051 | 6934 | 4068 | 1727 | 1200 | 22980 | 100 |
| **Pond water surface area (Ha.)** | | | | | | | |
| Mountains | 1.25 | 1.5 | 0 | 0 | 0.25 | 3 | 0.05 |
| Hills | 30.5 | 69 | 58 | 6.5 | 0 | 164 | 2.64 |
| Terai | 2186 | 2347 | 919 | 429 | 172 | 6053 | 97.32 |
| Total | 2217.75 | 2417.5 | 977 | 435.5 | 172.25 | 6220 | 100 |
| **Average pond size (Ha..)** | | | | | | | |
| Mountains | 0.125 | 0.06 | 0 | 0 | 0.05 | 0.075 | |
| Hills | 0.127 | 0.153 | 0.118 | 0.044 | 0.000 | 0.123 | |
| Terai | 0.248 | 0.363 | 0.257 | 0.272 | 0.144 | 0.280 | |
| Total | 0.245 | 0.349 | 0.240 | 0.252 | 0.144 | 0.271 | |
| **Fish production (mtons)** | | | | | | | |
| Mountains | 1.625 | 1.95 | 0 | 0 | 0.325 | 3.9 | 0.02 |
| Hills | 39.65 | 111.3 | 101.8 | 8.45 | 0 | 261.2 | 1.29 |
| Terai | 7025.98 | 7886.22 | 2983.46 | 1495 | 557.28 | 19947.94 | 98.69 |
| Total | 7067.26 | 7999.47 | 3085.26 | 1503.45 | 557.61 | 20213.04 | 100 |
| **Pond fish yield (mton/ha.)** | | | | | | | |
| Mountains | 1.30 | 1.30 | 0.00 | 0.00 | 1.30 | 1.30 | |
| Hills | 1.30 | 1.61 | 1.76 | 1.30 | 0.00 | 1.59 | |
| Terai | 3.21 | 3.36 | 3.25 | 3.48 | 3.24 | 3.30 | |
| Total | 3.19 | 3.31 | 3.16 | 3.45 | 3.24 | 3.25 | |

**Source: DOFD, HMG Nepal**

Table 5 (B). Other Aquaculture Practices in Different Geographical Locations of Nepal (2004/2005 AD)

| S. No. | Aquaculture Practices | Geographical Locations | | | | |
|---|---|---|---|---|---|---|
| | | Mountains | Hills | Terai | Total | Remarks |
| 1 | Cage Fish Culture in Lakes & Reservoirs | | | | | |
| | Cage Volume (M3) | | 36,000 | | 36,000 | |
| | Productions (Metric tons) | | 216 | | 216 | |
| | Yield (kg/M3) | | 6 | | 6 | |
| 2 | Enclosure Fish Culture in Lakes | | | | | |
| | Coverage Area (ha.) | | 100 | | 100 | |
| | Production (Metric tons) | | 130 | | 130 | |
| | Yield (kg/ha.) | | 1300 | | 1300 | |
| 3 | Rice-cum Fish Culture | | | | | |
| | Coverage Area (ha.) | | 194 | 83 | 277 | |
| | Production (Metric tons) | | 78 | 33 | 111 | |
| | Yield (kg/ha.) | | 402 | 398 | 401 | |
| 4 | Fish Culture in Gholes | | | | | |
| | Coverage Area (ha.) | | 140 | 1260 | 1400 | |
| | Production (Metric tons) | | 175 | 1603 | 1778 | |
| | Yield (kg/ha.) | | 1250 | 1272 | 1270 | |

Source: DOFD, HMG Nepal

Table 6(A): Aquaculture Production and Capture Fisheries by Species and Commodity Prices

| Particulars | Base Year | With Five Year Plan Accomplishment | | |
|---|---|---|---|---|
| | 2001/02 | 2002/03 | 2003/04 | 2004/05 |
| Aquaculture Practice | | | | 22480 |
| Cyprinids (Indigenous major carps) Labio, Cirhina, Catla etc. | | | | |
| Production (mt.) | 4965 | 5125 | 5798 | 6518 |
| Price (Rs./ kg) | 109.00 | 108.00 | 110.00 | 115.00 |
| Price ( US $ / kg) | 1.36 | 1.44 | 1.55 | 1.55 |
| Common carp- Cyprinus carpio | | | | |
| Production (mt.) | 3472 | 3591 | 4067 | 4581 |
| Price (Rs./ kg) | 100.00 | 100.00 | 100.00 | 100.00 |
| Price ( US $ / kg) | 1.25 | 1.33 | 1.41 | 1.35 |
| Bighead carp - Aristichthys nomilis | | | | |
| Production (mt.) | 2597 | 2682 | 3031 | 3403 |
| Price (Rs./ kg) | 90.00 | 80.00 | 85.00 | 90.00 |
| Price ( US $ / kg) | 1.13 | 1.07 | 1.20 | 1.20 |
| Grass carp - Ctenopharyngodon iddlus | | | | |
| Production (mt.) | 908 | 940 | 1066 | 1201 |
| Price (Rs./ kg) | 100.00 | 100.00 | 100.00 | 100.00 |
| Price ( US $ / kg) | 1.25 | 1.33 | 1.41 | 1.06 |
| Silver carp - Hypopthalmichthys mokitrix | | | | |
| Production (mt.) | 5158 | 5342 | 6038 | 6777 |
| Price (Rs./ kg) | 90.00 | 80.00 | 85.00 | 90.00 |
| Price ( US $ / kg) | 1.13 | 1.07 | 1.20 | 1.20 |
| Capture Fisheries | | | | |
| Fresh water indigenous fish species - Schizothorax spp., Tor spp., Neolissocheilus spp., Anguillla spp., Mastacembelus spp., Ophiociphalus spp., Puntius spp., Garra spp., etc. | 17900 | 18888 | 19947 | 19983 |
| Price (Rs./ kg) | 150.00 | 150.00 | 160.00 | 160.00 |
| Price ( US $ / kg) | 1.88 | 2.00 | 2.26 | 2.26 |

Source: DOFD, HMG Nepal

Table 6(B): Fish Production (Commodity wise) from Aquaculture and Fisheries in Nepal

| Local Name | Scientific Name | Base Year | Production ( metric tons) | | |
|---|---|---|---|---|---|
| | | 2001/02 | 2002/03 | 2003/04 | 2004/05 |
| Aquaculture Practices | | 17100 | 17680 | 20000 | 22480 |
| Pond Fish Culture | | 15556 | 16037 | 18060 | 20245 |
| Common carp | Cyprinus carpio | 3110 | 3210 | 3615 | 4052 |
| Silver carp | Hypopthalmichthys molitrix | 4660 | 4810 | 5417 | 6072 |
| Bighead carp | Aristichthys nobilis | 2330 | 2405 | 2708 | 3036 |
| Grass carp | Ctenopharyngodon iddlus | 780 | 802 | 903 | 1012 |
| Rohu | Labeo rohita | 2340 | 2405 | 2708 | 3036 |
| Naini (Mrigal) | Cirihinus mrigala | 1560 | 1604 | 1806 | 2025 |
| Bhakur (Catla) | Catla catla | 776 | 801 | 903 | 1012 |
| Paddy cum fish culture | | 64 | 64 | 87 | 111 |
| Common carp | Cyprinus carpio | 64 | 64 | 87 | 111 |
| Enclosures and pens | | 130 | 130 | 130 | 130 |
| Common carp | Cyprinus carpio | 39 | 39 | 38 | 38 |
| Silver carp | Hypopthalmichthys molitrix | 58 | 58 | 60 | 60 |
| Bighead carp | Aristichthys nobilis | 22 | 20 | 20 | 20 |
| Grass carp | Ctenopharyngodon iddlus | 11 | 13 | 12 | 12 |
| Cages | | 180 | 195 | 204 | 216 |
| Common carp | Cyprinus carpio | 25 | 28 | 24 | 25 |
| Silver carp | Hypopthalmichthys molitrix | 90 | 98 | 105 | 111 |
| Bighead carp | Aristichthys nobilis | 65 | 69 | 75 | 80 |
| Marginal swamps/gholes | | 1170 | 1254 | 1519 | 1778 |
| Common carp | Cyprinus carpio | 234 | 250 | 303 | 355 |
| Silver carp | Hypopthalmichthys molitrix | 350 | 376 | 456 | 534 |
| Bighead carp | Aristichthys nobilis | 180 | 188 | 228 | 267 |
| Grass carp | Ctenopharyngodon iddlus | 117 | 125 | 151 | 177 |
| Rohu | Labeo rohita | 145 | 125 | 151 | 177 |
| Naini (Mrigal) | Cirihinus mrigala | 96 | 125 | 151 | 177 |
| Bhakur (Catla) | Catla catla | 48 | 65 | 79 | 91 |
| Capture Fisheries | | | | | |
| Rivers, lakes, reservoirs, irrigated paddy fields, swamps, ditches etc. | | 17900 | 18888 | 19947 | 19983 |
| Major Species are; | | | | | |

Asala- Schizothorax spp. ; Sahar- Tor spp. ; Katle- Neolissocheilus spp.;
Bam- Anguilla spp, Mastacembelus spp; Hilley- Ophiocephalus spp; Potia- Puntius spp. ; Chinese and Indigeneous Major Carps
Source: DOFD, HMG Nepal

| Table 7(A): Input Supply (Fish Seed) in Aquaculture Delivered by Government Institutions | | | | | | | |
|---|---|---|---|---|---|---|---|
| Particulars | Base Year | With Five Year Plan | | | | | Increasement % against Base Year |
| | | Accomplishment | | | Projected | | |
| | 2001/02 | 2002/03 | 2003/04 | 2004/05 | 2005/06 | 2006/07 | |
| Fish seed ( Nos. in 000's) | 74600 | 75515 | 82230 | 85640 | 88079 | 94097 | 26 |
| Public Sector | 17586 | 19817 | 22926 | 22906 | 25317 | 24840 | 41 |
| Private Sector | 57014 | 55698 | 59304 | 62734 | 62762 | 69257 | 21 |
| Share of Private Sector (%) | 76 | 74 | 72 | 73 | 71 | 74 | -4 |

| Table 7(B): Fish Seed Production and Distribution in Aquaculture and Fisheries in Nepal | | | | | |
|---|---|---|---|---|---|
| Local Name | Scientific Name | Base Year | With Five Year Plan (Number Released in '000s) | | |
| | | | Accomplishment | | |
| | | 2001/02 | 2002/03 | 2003/04 | 2004/05 |
| A. Aquaculture practices | | | | | |
| Common carp | Cyprinus carpio | 18650 | 18880 | 20559 | 21412 |
| Silver carp | Hypopthalmichthys molitrix | 18650 | 18880 | 20559 | 21412 |
| Bighead carp | Aristichthys nobilis | 11190 | 11325 | 12332 | 12843 |
| Grass carp | Ctenopharyngodon iddlus | 3730 | 3775 | 4111 | 4281 |
| Rohu | Labeo rohita | 11190 | 11325 | 12332 | 12843 |
| Naini (Mrigal) | Cirihinus mrigala | 7460 | 7555 | 8226 | 8568 |
| Bhakur (Catla) | Catla catla | 3730 | 3775 | 4111 | 4261 |
| | Total | 74600 | 75515 | 82230 | 85620 |
| B. Stock enhancement in the wild (Fisheries) | | | | | |
| Local Name | Scientific Name | Base Year | With Five Year Plan (Number Relesed in '000s) | | |
| | | | Accomplishment | | |
| | | 2001/02 | 2002/03 | 2003/04 | 2004/05 |
| Asala | Schizothorax spp. | 2000 | 2000 | 2000 | 2000 |
| Sahar | Tor spp. | | | | |
| Katle | Neolissocheilus spp. | | | | |
| | Total | 2000 | 2000 | 2000 | 2000 |
| Source: DOFD, HMG Nepal, based on FAO Fishstat | | | | | |

| Table 8: Preliminary Estimate of Livestock and Fishery Statistics | | | | |
|---|---|---|---|---|
| Particulars | Base Year | With Five Year Plan Accomplishment | | |
| | 2001/02 | 2002/03 | 2003/04 | 2004/05 |
| Milk Production (mt.) | 1158788 | 1195931 | 1231853 | 1274228 |
| Meat Production (mt.) | 198644 | 203899 | 208412 | 214817 |
| 2.1 Buffallo | 127495 | 130791 | 133600 | 138953 |
| 2.2 Sheep | 2823 | 2792 | 2779 | 2744 |
| 2.3 Goat / Mutton | 38584 | 39664 | 40540 | 41698 |
| 2.4 Pig | 15594 | 15626 | 15389 | 15724 |
| 2.5 Chicken | 13891 | 14756 | 15881 | 15461 |
| 2.6 Duck | 257 | 270 | 223 | 237 |
| Egg Production ('000 No.) | 538424 | 557361 | 575565 | 590137 |
| Fish Production (mt.) | 35000 | 36568 | 39947 | 42463 |
| 4.1 Aquaculture | 17100 | 17680 | 20000 | 22480 |
| 4.2 Capture Fisheries | 17900 | 18888 | 19947 | 19983 |

Source: MOAC, Agri. Statistics Division, HMG Nepal

***Reproduced from Aquaculture Asia: Cage fish culture- a successful income generation in reservoir Kulekhani, Markhu, Nepal***

*By Ash Kumar Rai*, Suresh Kumar Wagle*

Abstract:

Kulekhani reservoir impounded in 1982 offers a very good example of an effective secondary utilization of a reservoir resource for fish production and maintaining the livelihoods of poorer sectors of the population living in its vicinity. As a result of the successes of the cage culture R & D trials initiated through the IDRC (Canada) this activity has become the main livelihood of 166 families. A total cage volume of 34,048 $m^3$ operates in the reservoir yielding more than 136 t fish annually which is equivalent to NRs 10,880,000.00 (@ NRs 80/kg) = US$ 155,429.00). It has been demonstrated that fish culture activity is far more profitable than any other agricultural activity in the area.

Introduction

Nepal is very rich in its water resources, possessing about 2.27% of the world water resources (CBS 2005). Out of total 818,500 ha of total water surface area, fish ponds cover about 6500 ha producing about 20,000 Mt annually (DoFD 2061/'62). Aquaculture has been concentrated in pond fish culture particularly in the southern region. Of the lakes and reservoir most fishery developments have occurred in the Pokhara valley lakes and the Kulekhani reservoir in the central of the mi-hill region.

Reservoirs acreage in Nepal is about 1,500 ha and that of Kulekhani reservoir is about 220 ha. Kulekhani reservoir (126 $mk^2$ catchment) was impounded in 1982 by damming main Kulekhani river and its tributaries at an elevation 1430 msl. It is located about 83 km south-west of Kathmandu city in Markhu, Makwanpur district. This is the first large sized reservoir constructed in the hilly region of Nepal, and was for electricity generation. about the reservoir is characterized by a draw down of about 54 m resulting in a range of 220 ha to 75 ha surface area (Fig. 1).

Kulekhani reservoir is the first man made reservoir to explore aquaculture development as meands of providing livelihoods to displaced persons and people living in the vicinity. This development program was initiated by the government with technical assistance from the International Development Research Centre (IDRC), Canada in 1984. The project was visualized to assess the feasibility for fisheries development program by gathering in-depth information on the limnological/biological parameters and also to help and lay out the foundation for the future reservoir fisheries development programs in the country.

Water quality parameter

The annual water temperature in the reservoir ranges from 12.0$^0$C during January/February to 25.5$^0$C during July/August. Dissolved oxygen does not fluctuate significantly and distribution ranges from above 7.0 to 8.7 mg/L in surface waters to below 60 m depth during January/February; however, the fluctuation is very high from 0 to 11.2 mg/l during May, June, July, and August. Transparency ranges from 1.2-3.4 m in June to January/February. Alkalinity ranges from above 28.6 to 80.0 mg/l in surface to bottom. The annual pH remains 7.5-9.8. Total hardness ranges 30-66 mg/l. The carbon production ranged from 350 mg/m$^2$/day during October to 3,000 mg/m$^2$/day in April (Rai 1989).

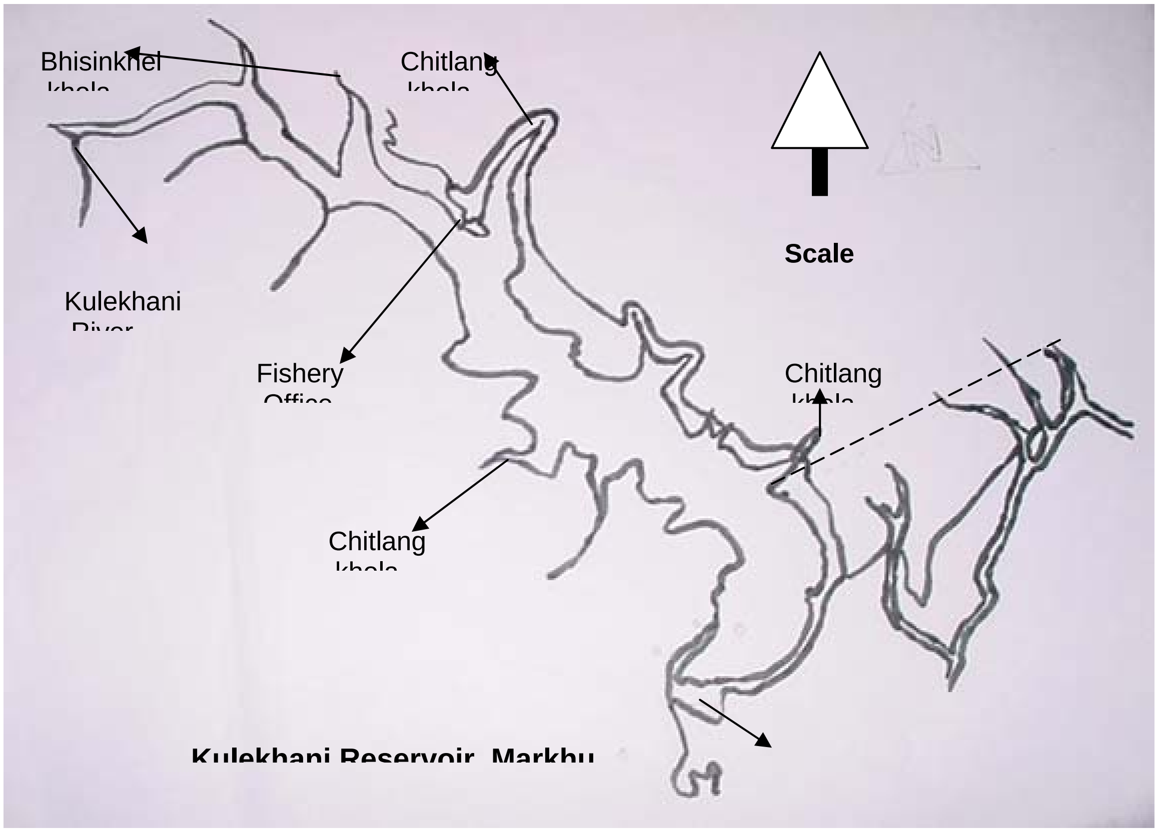


Figure 1**.** Map of Kulekhani Reservoir

Eleven zooplankton species have been identified the most dominant being *Keratella* (about 51%) followed by *Cyclops* spp. (14%) abundant in July to September and least abundant during December and March (Pradhan 1986/'87). Total zooplankton density about 682 No/L was highest during October and lowest about 131 No/L during December. *Cyclops* density was highest (35 No/L) during October followed by nauplius (244 No/L). Eighteen phytoplankton  species have been identified the most prominent being *Peridinium*, *Anabaena*, *Melosira*, *Synedra* and *Staurastrum* (Pradhan 1986/'87). Phytoplankton was most abundant during May, June, July, October and September and least during January, and February.

<u>Fish catch composition</u>

The three main fish species available in Kulekhani reservoir are Katle Neolissocheilus hexagonolepis with a  highest monthly catch of more than 41-89% followed by Karange Puntius chilinoides (11-69.9%)  and  Asla Schizothorax spp ( 0.5-7%). Sahar Tor putitora was very rare. The total fish catch from the reservoir is about 3-4 t during June/July mostly Katle (Rai 1989). Katle catch was higher during September, January, and June and less during July, April and December. Size of Katle can be up to 2.9 kg and male is smaller than female and mature during June to August at about 700 g size. Karange catch was higher during July, April, and May. Karange sizes range from 13-900 g . Karange spawns during January to March and spawn in flowing water exposing half the body out of the water. Asla catch was highest in May but have decreased year by year . Size of asla ranged from 15-200 g and matures twice a year December/January and April/may and spawn in flowing clear water. The exotic fish silver carp and bighead carp favour the water body in the reservoir and grow well. These grows up to about 9 kg within 3 years and the indigenous carp rohu (Labeo rohita) and bhakur (Catla catla) also showed better growth but less than silver and bighead carps. Rohu attained 1.6 kg in 4 years and bhakur 1.5 kg within 3 years.

The local fish species katle, karange and asla were affected greatly after damming of the Kulekhani river. Before damming Kulekhani was famous for asla , an algal feeder, but after damming population has ecreased due to environmental changes and disturbances to the breeding grounds. Katle and karange are omnivorous and are suitable for developing a fishery supported by a well planned stoick enhancement strategy. Asla ont the other hand, do not perform well in the reservoir due to lack of running fresh water and preferred habitats with stones covered with algal mats.

Cage fish culture

Cage fish culture started using silver and bighead carps during late 1980s on an experimental scale. The cage culture technology has been developed in the lakes of Pokhara valley in Nepal and the technology was applied successfully by the farmers in the valley. This technology was applied in Kulekhani reservoir. Cage culture production was high about 5 kg/m3 with silver and bighead carps together cultured singly (4 kg/m3 ) (Rai 1989), indicating better utilization of available natural food items r. The average growth rate was 2.8 g/day with highest growth rate about 8.4 g/day during April to May but lost in weight during January/February when water temperature falls below 140C (Rai 1989/'90).

Cage culture gradually became successful in the reservoir providing job opportunities to the local people and uplifting incomes and supporting their livelihoods. Now there are 212 farmers (100 females and 112 males) involved in cage fish culture using 32,024 m3 for production and 7,104 m3 for nursery and grow-out (Fig. 2). About 166 members are involved in 10 fishermen associations. In addition, about 2,024 m3 production cages and 1021 nursery and rearing cages are used by the public sector, as demonstration and fry to fingerling rearing for distribution to prospective farmers. Accordingly, a total cage volume of 34,048 m3 in the reservoir produce more than 136 t fish annually which is equivalent to NRs 10,880,000.00 (@ NRs 80/kg) = US$ 155,429.00).


Figure 2. Cage culture activities in Kulekhani Reservoir

Kulekhani reservoir is eutrophic. The organic fertilizer primarily from domestic animals run off during the rainy season from the surrounding villages makes the reservoir fertile and the resulting phyto- and zooplankton provide a rich food source for the cultured fish species like silver carp, bighead carps, etc. The caged fish growth is depended entirely on the natural food developed within the reservoir. The fish growth is better above 200C when plankton population also is high. Growth of silver and bighead carps is shows a direct relationship to the water temperature and the plankton density. Indigenous carps rohu and bhakur also show favourable growth in the reservoir and performs better in open water than in cages. About 49% of people living around the reservoir have benefited directly from cage culture in the reservoir, providing their livelihoods and better incomes than before.

Socio-economics

The average family size is 6.5 of the population living around the reservoir. The average size of land holding was 0.77 ha withan average number of 3 large and 6 small live stocks but with only 0.12 ha of per capita available cultivated land (Adhikari 1988). The cost and return evaluated from the crop and vegetable shows that the average net return varied from NRs 7,167/10,000 m2 for cereal crops, NRs 5611/10,000 m2 for oilseeds and NRs 19,784/10,000 m2 for potato, respectively and in cage fish culture, the net return was be NRs 2,644/18m3 (NRs 147/m3) (Adhikari 1995). However, the land size is decreasing trend due to increasing human population and the cage fish culture activity will be the best alternative source for supporting livelihoods of the people living around the reservoir.

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# Sri Lanka

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### *Introduction*

<u>The Fisheries Sector</u>

The Fisheries sector of Sri Lanka is of considerable social and economic importance as it contributes around 70% of the animal protein consumed in the country. In 2004 the total fish production was 286,370 tons accounting for 84% of the total quantity of fish consumed. This production declined by 43% in the year 2005 due to effects of the Tsunami which devastated the North Eastern and the Southern coastal belt of the country to 163,230 tons. However, it is expected to recover to 2004 levels by the end of 2006. The Annual per Capita Availability of Fish and Fishery Products in the recent past varied between 17.5 kg & 18.5 kg[3], but dropped to 14kg after the Tsunami (1).

Marine capture fisheries are the mainstay and the major economic activity of the people living in coastal areas. Likewise, capture fisheries from irrigation tanks and reservoirs and culture based fisheries in seasonal and minor perennial tanks combined with agriculture, are major livelihood activities among rural folk living around inland reservoirs and tanks mainly in the dry zone. Both marine and inland fishing sectors at present employs around 150,000 people, while another 100,000 approximately are employed in numerous fishery related activities. Apart from this another 400,000 approximately are self employed. The sector provides sustenance to at least 2.4 million persons in the fishing households throughout the country.

Marine fisheries have also emerged as a dynamic export oriented sector during the past decade earning valuable foreign exchange to the country. During the years 2000 to 2004, foreign exchange earnings through export of fish and marine products varied between US $ 83 Mn and US $ 100.8 Mn. The percentage contribution to total exports of the country varied between 1.56% and 2.47%.

<u>Water Resources in Sri Lanka</u>

The development of water resources has been one of the fields in which rare skills have been displayed by the people of Sri Lanka from ancient times (2). The dry zone of Sri Lanka consists of thousands of ancient tanks of varying sizes and shapes. Of these, some are operational while others are abandoned and the economy and human settlements of ancient Sri Lanka grew and flourished around these tanks. Leach, 1959, characterizes these early societies as ‘hydraulic civilizations’. These ‘hydraulic societies’ developed their livelihoods based on reservoir systems and water control devises (Biso kotus), which over the years developed into complex irrigation systems and hydroelectric generation schemes, around which the economy of present day Sri Lanka revolves even today.

The early Aryan settlers who possessed knowledge of irrigation and rice cultivation settled in the interior of Sri Lanka on flat, dry zone plains, ideal for rice cultivation. The dry plains being subject to periodic droughts, the settlers devoted their time and energies to conserve water by harnessing the rainwater or through diversion of streams and rivers into reservoirs (4). The Kings who ranked highest among Monarchs for their engineering skills were Mahasena (274 – 301 AD) and King Parakrama Bahu 1 (1153 – 1186AD). Among the reservoirs built by these two Kings are Minneriya and Padaviya (King Mahasena) and Parakrama Samudra (King Parakrama Bahu 1), which serves the nation even today (2).

Table 1: River Basins in Sri Lanka (Irrigation Department)

| Basin No. | Name of River | Catchment Area km$^2$ | Basin No. | Name of River | Catchment Area km$^2$ |
|---|---|---|---|---|---|
| 1 | Kelani Ganga | 2292 | 52 | Mundeni Aru | 1295 |
| 2 | Bolgoda Ganga | 378 | 53 | Miyangolla Ela | 223 |
| 3 | Kalu Ganga | 2720 | 54 | Maduru Oya | 1559 |
| 4 | Bentara Ganga | 629 | 55 | Pulliyanpota | 53 |
| 5 | Madu Ganga | 60 | 56 | Kirimechchi Odai | 78 |
| 6 | Madampe Lake | 90 | 57 | Bodigoda Aru | 165 |
| 7 | Telwatta Ganga | 52 | 58 | Mandan Aru | 13 |
| 8 | Ratgama Lake | 10 | 59 | Makarachchi Aru | 37 |
| 9 | Gin Ganga | 932 | 60 | Mahaweli Ganga | 10448 |
| 10 | Koggala Lake | 65 | 61 | Kantalai Aru | 450 |
| 11 | Polwatta Ganga | 236 | 62 | Palampotta Aru | 70 |
| 12 | Nilwala Ganga | 971 | 63 | Panna Oya | 145 |
| 13 | Sinimodara Oya | 39 | 64 | Pankulam Aru | 380 |
| 14 | Kirama Oya | 225 | 65 | Kunchikumban Aru | 207 |
| 15 | Rekawa Oya | 76 | 66 | Palakutti Aru | 21 |
| 16 | Urubokka oya | 352 | 67 | Yan Oya | 1538 |
| 17 | Kachigal Ara | 222 | 68 | Mee Oya | 91 |
| 18 | Walawe Ganga | 2471 | 69 | Ma Oya | 1036 |
| 19 | Karagan Oya | 58 | 70 | Churiyn Aru | 75 |
| 20 | Malala Oya | 404 | 71 | Chavar Aru | 31 |
| 21 | Embilikala Oya | 60 | 72 | Palladi Aru | 62 |
| 22 | Kirindi Oya | 1178 | 73 | Munidel Aru | 189 |
| 23 | Bambawe Aru | 80 | 74 | Kodalikallu Aru | 75 |
| 24 | Mahasilawa Oya | 13 | 75 | Per Aru | 378 |
| 25 | Butawa Oya | 39 | 76 | Pali Aru | 85 |
| 26 | Menik Ganga | 1287 | 77 | Maruthapilly Aru | 41 |
| 27 | Katupila Ara | 86 | 78 | Thoravil Aru | 90 |
| 28 | Kuranda Ara | 132 | 79 | Piramenthal Aru | 83 |
| 29 | Namadagas Ara | 109 | 80 | Nethali Aru | 122 |
| 30 | Karambe Ara | 47 | 81 | Kanakarayan Aru | 906 |
| 31 | Kumbukkan Oya | 1233 | 82 | Kalawalappu Aru | 57 |
| 32 | Batura Oya | 93 | 83 | Akkarayan Aru | 194 |
| 33 | Girikula Ara | 15 | 84 | Mandekal Aru | 300 |
| 34 | Helawa Ara | 51 | 85 | Pallavarayan Kadu | 160 |
| 35 | Wila Oya | 489 | 86 | Pali Aru | 456 |
| 36 | Heda Oya | 611 | 87 | Chappi Aru | 67 |
| 37 | Karanda Oya | 427 | 88 | Parangi Aru | 842 |
| 38 | Simena Ara | 52 | 89 | Nay Aru | 567 |
| 39 | Tandiadi Ara | 22 | 90 | Mavatu Oya (Aruvi Aru) | 3284 |
| 40 | Kangikadichchi Ara | 57 | 91 | Kal Aru | 212 |
| 41 | Kurus Kulam | 35 | 92 | Modaragam Aru | 44 |
| 42 | Pannela Oya | 186 | 93 | Kala Oya | 2805 |
| 43 | Ambalam Oya | 116 | 94 | Moongil Aru | 44 |
| 44 | Gal Oya | 1873 | 95 | Mi Oya | 1533 |
| 45 | Andella Oya | 528 | 96 | Madurankuli Aru | 44 |
| 46 | Tumpankeni | 9 | 97 | Kalagamune Oya | 153 |
| 47 | Namakada Aru | 11 | 98 | Rathambala Oya | 217 |
| 48 | Mandipattu Aru | 101 | 99 | Deduru Oya | 2647 |

| | | | | | |
|---|---|---|---|---|---|
| 49 | Pathantoddathane Aru | 101 | 100 | Karambala Oya | 596 |
| 50 | Vett Aru | 26 | 101 | Ratmal Oya | 217 |
| 51 | Unnichchai | 350 | 102 | Maha Oya | 1528 |
| | | | 103 | Attanagalu Oya | 735 |
| | | | | **All Basins** | **59245** |

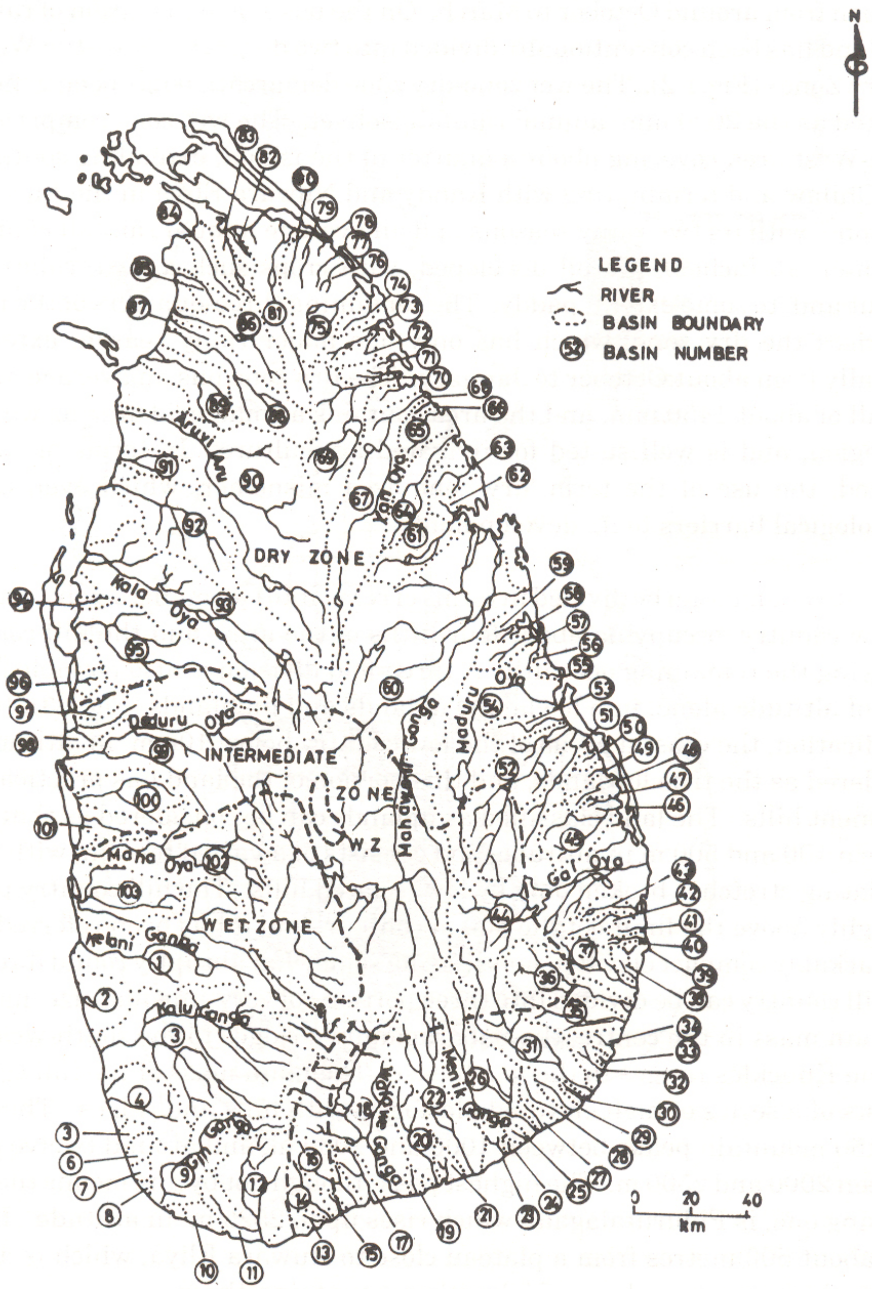



Figure 1. River Basins of Sri Lanka

Sri Lanka comprises of 103 distinct river basins (Table 1), with most rivers having their origin in the central highlands flowing down to the sea (Fig 1). The longest river is the Mahaweli Ganga with a length of 355 km, which drains an area of 10,448 km², comprising nearly one-sixth the entire area of the country. The other long rivers are the Malwathu Oya, the Kala Oya, the Kelani Ganga, the Yan Oya, the Deduru Oya and the Walawe Ganga, all of which have lengths varying from 140 and 160 kms. The river basins vary in size from about 9 sq km to more than 10,000 sq km (2).

This system of river basins is endowed with a high water balance compared to many other countries in the world and with proper utilization has the potential to sustain the various needs of the country in large measure. A map titled 'Planned River Basin Development' of Sri Lanka had been prepared in 1959 and with periodic modification served as a guide to planned river basin development in Sri Lanka, with particular emphasis on irrigation and hydropower generation. All possible reservoir sites had been selected and investigated and the development of water resources for irrigation and hydropower generation had been taken up on a large scale to meet the requirements of an ever-increasing population (2).

The four major regions in Sri Lanka for the purpose of water resources development were as follows (2):

- **Mahaweli Project Region:** This comprises of the administrative districts of Nuwara Eliya, Kandy, Matale, Badulla, Polonnaruwa, Anuradhapura, Vavuniya and Udawalawe. It covers a gross land area of 25,500 sq.km, which is 38% of the total land area of Sri Lanka. The completed reservoirs under this are, Bowatenna, Dambulu Oya Reservoir, Kandalama Reservoir, Huruluwewa Reservoir, Kalawewa Reservoir, Polgolla, the Victoria, Kothmale, Maduru Oya, Randenigala Dam, Rantambe Dam and the Minipe Anicut.
- **South-East Dry Zone Region**: The administrative area covered by this region comprises districts of Moneragala, Batticaloa and Hambantota. It has nearly15,200 sq.km, which is around 23% of the total land area of Sri Lanka. The completed reservoirs in this region are, the Udawalawe Reservoir (268mn m³), the Chandrika wewa (29mn m³), the Samanala Wewa, Lunugamvehera Reservoir (222mn m³), the Muruthawela Reservoir (48mn m³), Ridiyagama tank (27mn m³) Muthukandiya Reservoir (25mn m³), Senanayake Samudra (950mn m³), Navakiri Ara Reservoir (52mn m³), Unnichchai Reservoir (47mn m³), the Rugam tank (23mn m³)and the Rambukkan Oya Reservoir.
- **Western Wet Zone Region:** This region comprises the districts of Colombo, Gampaha, Kalutara, Kegalle, and Ratnapura, Galle & Matara. The total extent of this area is around 11,480 km², which is about 17.7% of the total land area of Sri Lanka. The river systems in this region are the Niwala Ganga (annual runoff 1379mn m³), Gin Ganga (annual runoff 2178mn m³), Bentota Ganga (annual runoff 1247mn m³), Kalu ganga (annual runoff 8183mn m³), Kelani Ganga (annual runoff 5579mn m³). The completed reservoirs from this river basin are the Mousakelle Reservoir and the Castlereigh, which were constructed for mainly power generation.
- **North-West dry Zone Region:** This region comprises districts of Jaffna, Vanni, Puttalam and Kurunegala. The total area of this region is around 16,435Km ², which is about 25% of the land area of Sri Lanka. The major rivers in the region are Maha Oya (annual runoff 1485mn m³), Deduru Oya (annual runoff 1129mn

m³, with two anicuts, Deduru Oya anicut and Ridibendi anicut and 4 reservoirs, namely Batalagoda,Hakwatuna Oya, Magalle Wewa, & Kimbulwana Oya), Mi Oya (annual runoff 198mn m³), Kala Oya (cathment has a number of reservoirs namely Kalawewa, Rajangane, Angamuwa, Kandalama, Dewahuwa, & Dambulu Oya) , Modaragam Aru (annual runoff 169km³), Malwathu Oya (annual runoff 566mn m³ with larger reservoirs in its basin namely, Nachchaduwa,Tissawewa, Nuwerawewa, Basawakkulama, Mahakanadarawa, Pavatkulam, Giant's tank and Iratperiyakulam), Parangi Aru (runoff 112mn m³), Pali Aru and Kanagarayan Aru (annual runoff 242mn m³).

Utilization of Water Resources

The primary utilization of water resources is for domestic consumption such as drinking, culinary uses, washing, bathing, and laundering and for watering plants and lawns. The responsibility of utilizing surface and ground water through water supply schemes lies with the National Water Supply and Drainage Board of Sri Lanka. It has already established a number of water supply schemes for urban as well as for rural Sri Lanka. Where there is no supply of water through schemes, people obtain their water from private as well as public wells. The quality of water of such wells remains questionable.

Water utilization is also of paramount importance to the industrial sector. However, the supply of water for such industries has not posed a problem so far as most of the industries requiring large quantities of water have been located close to surface or ground water sources.

The third most important aspect of water utilization is irrigation of cultivable land around which the economic and social aspects of Sri Lanka revolves. Irrigation water is conveyed to cultivable land, by flood, furrow, sprinkler and drip systems. The other irrigation method is lift irrigation from agro wells, mostly practiced in the North. For large-scale cultivation such as paddy and other crops, irrigation from canal systems leading from reservoirs is mostly practiced in the dry zone. Such irrigation works are classified from an engineering perspective into three main groups (5), vis-à-vis Village Irrigation Works, Medium and Major Irrigation Works.

Village Irrigation Works are those, which serve a command area of less than 80ha. Deliveries of water are made from a supply canal to a block of several holdings and to individual holdings. The village works also has the function of providing drainage facilities, mitigation of floods and control of erosion through trapping of silt.

Medium Irrigation Works are those schemes, which assure irrigation waters or provide flood mitigation to an area of over 80ha, but less than 600ha. Farms under the medium irrigation works are supplied with water from a network of canals.

The Major Irrigation Works are those, which assure irrigation waters or provide flood mitigation measures to an area of over 600ha. The method of irrigating farms of new and existing lands is similar to that for the medium irrigation works.

Utilization of Water Resources for Inland Fisheries & Aquaculture

Sri Lanka does not have natural lakes other than flood plains or villus formed by runoff from major rivers. There are no natural lake fish species in inland waters in Sri Lanka and as a result, a capture fishery was non-existent till the early fifties before the introduction of Oreochromis mossambicus to man made reservoirs. However, none of the reservoir systems in Sri Lanka have been designed for inland fisheries. The main reason being that capture fisheries has not been practiced as a tradition due to the afore said reason, by the farming community, who were mainly agricultural farmers. However, some historic ancient manuscripts make reference to payment of taxes by the agricultural community from proceeds of sale of fish obtained from certain reservoirs in ancient Anuradhapura (6).

Till late 70's, there had been a capture fishery at the subsistence level after the introduction of Oreochromis mossambicus to Sri Lanka inland waters, in mid to late 50's. Presently this has developed in to a major activity contributing 12 % to the total fish production in the country. The classification of the Ministry of Fisheries & Aquatic Resources, Sri Lanka, categorizes inland water bodies for the purpose of inland fisheries and aquaculture, as follows;

- Large Irrigation Reservoirs with an area of over 800 ha
- Medium Irrigation Reservoirs with an area of between 200 & 800ha
- Minor Irrigation Reservoirs with an area of between 80 & 200ha
- Seasonal Tanks with an area of less than 80ha
- Mahaweli Reservoirs with an area between less than 80ha and over 800ha.

The Figure 2 illustrates the major reservoirs in Sri Lanka.

Accordingly, the reservoir type with their respective areas is given below;

Table 2: **Water Resources in Sri Lanka**

| **Resource Type** | **Area (ha)** |
|---|---|
| Large Irrigation Reservoirs | 70,850 |
| Medium Irrigation Reservoirs | 17,004 |
| Minor Irrigation Reservoirs | 39,271 |
| Seasonal Village Tanks | 100,000 |
| Flood Lakes (Villus) | 4,049 |
| Upland Reservoirs (Estate Tanks) | 8,097 |
| Mahaweli Reservoirs | 34,261 |
| Total (freshwater) | 273,532 |
| Total (brackish water) | 150,000 |

(Source: Ministry of Fisheries & Aquatic resources)


Figure 2: Major Reservoirs in Sri Lanka

<u>Fish Consumption Patterns</u>

Household Income

In reviewing fish and other food consumption patterns of households in Sri Lanka, it is relevant to first look at the general household income and expenditure in order to understand the significance of the general behavioral patterns in food consumption preferences of the households in Sri Lanka. Household income can be defined as the income received by all members of the household from various sources inclusive of not only the monetory income, but also non-monetory income. A survey conducted by the Department of Census and Statistics, Sri Lanka (7) from September to

Table 3: Median household income per month (in Rs) by sector – 2005 (Source: Department of Census & Statistics)

| Sector | 2005 | 2002 |
|---|---|---|
| Sri Lanka | 20,048.00 | 12,803.00 |
| Urban | 31,239.00 | 22,420.00 |
| Rural | 18,634.00 | 11,712.00 |
| Estate | 12,070.00 | 7,303.00 |

November 2005 to capture income and expenditure patterns after the Tsunami, revealed that the average household income per month was Rs. 20,048.00 in the year 2005, when compared to the year 2002 in which year the income was Rs. 12,803.00. According to the survey, the percentage increase of household income at the 2005 prices was 57% and the percentage increase in real terms, after removing the effects of inflation was 21%. According to the survey results, the urban sector households have received an average income of Rs. 31,239.00 and the rural sector households have received an average income of Rs. 12,070.00 per month.

The survey further revealed that the median household income per month for Sri Lanka was Rs. 13,617.00, which meant that 50% of the households in Sri Lanka had received less than Rs. 13.617.00 per household per month in the year 2005, when compared to the income received in 2002, which was Rs. 8,482.00. Also according to the survey, the average per capita income which is estimated by dividing the income of all households by the estimated number of household population was Rs. 4,896.00 per month for Sri Lanka in 2005 compared to Rs. 3,056.00 in 2002. In real terms the percentage increase was 24%.

Table 4: Mean per capita income per month (in Rs) by sector 2002 and 2005 (Source: Department of Census & Statistics)

| Sector | 2005 | 2002 |
|---|---|---|
| Sri Lanka | 4,896.00 | 3,056.00 |
| Urban | 7,318.00 | 4,997.00 |
| Rural | 4,601.00 | 2,835.00 |
| Estate | 2,770.00 | 1,663.00 |

Household Expenditure

The same survey conducted by the Department of Census & Statistics revealed that the mean household expenditure per month was Rs. 19,151.00 in 2005, of which a sum of Rs. 7,593.00 was spent on food and drink, which was around 39.6% of the total expenditure.

Table 5: **Mean Household expenditure per month (Rs) by sector in 2002 and 2005 (Source: Department of Census & Statistics)**

| Sector | 2005 | 2002 |
|---|---|---|
| Sri Lanka | 19,151.00 | 13,147.00 |
| Urban | 26,529.00 | 22,196.00 |
| Rural | 18,292.00 | 12,063.00 |
| Estate | 12,685.00 | 8,786.00 |

Expenditure on non-food items was reported to be Rs. 11,558.00 per month. Of this value, a sum of Rs. 479.00 was spent on liquor and tobacco, which was 4% of the non-food expenditure. A comparison of the above values with that in the year 2002 is represented in the following Table.

Consumption of selected food items

In the year 2005, the per capita expenditure on food was reported as Rs. 1,854.00 per month. The mean per capita consumption of rice per month was 8.7kg and that of bread was 1.8kg. When compared to 2002, the per capita consumption of bread decreased by 25%, while that of rice increased by 4%. Per capita consumption of selected food items is given below.

Table 6: Per capita consumption (g), per month of selected food items - 2005 (Source: Department of Census & Statistics)

| Item | Quantity | Value Rs. |
|---|---|---|
| Total Food expenditure | - | 1,854.00 |
| Rice (Samba) | | |
| Rice (Samba) | 1,251 | 46 |
| Rice (Kekulu) | 3,196 | 92 |
| Wheat Flour | 4,249 | 118 |
| Bread (normal) | 763 | 23 |
| Dhal | 1,796 | 67 |
| Big onions | 539 | 44 |
| Sugar | 534 | 25 |
| Coconut | 1,373 | 61 |
| Vegetables | 07 | 105 |
| **Fresh Fish** | - | 151 |
| **Dried Fish** | **933** | **158** |
| | **308** | **71** |

Table 7: Average household expenditure per month on selected

| Item | Sri Lanka | Sector Urban | Rural | Estate |
|---|---|---|---|---|
| Rice (Kekulu) | 484 | 316 | 520 | 359 |
| Rice (Samba) | 190 | 338 | 172 | 70 |
| Rice (Nadu) | 375 | 216 | 384 | 675 |
| Wheat Flour | 94 | 76 | 72 | 510 |
| Bread (normal) | 273 | 399 | 261 | 123 |
| Dhal | 179 | 171 | 180 | 193 |
| **Fish (fresh)** | **647** | **965** | **619** | **215** |
| **Fish (dried)** | **290** | **222** | **308** | **185** |
| Coconuts | 429 | 420 | 435 | 347 |

<u>Food items by sector – 2005</u>

When sectors are compared, it was seen that the households in the estate sector consume more wheat flour and rice than in the other two sectors. The consumption of fish, fresh and in the dried form was comparatively less than the other two sectors (7).

The marine and inland fish production in 2004 was 286,370 tons and this production drastically reduced in the year 2005 to 163,230 tons due to the effects of the Tsunami. The reduction in fish production was mainly from the marine fisheries sector, which decreased to 130,400 tons in 2005 from 253,190 tons produced in 2004. The inland fish production which represent around 12% of the total fish production in the country only decreased marginally due to a reduction in the coastal aquaculture production comprising mainly shrimp aquaculture, due to the onset of disease outbreaks due to 'White spot' virus. The fish production in the years 2004, 2005 and from Jan to Nov 2006 is given below (8).

Table 8: Fish Production 2005 Source: Ministry of Fisheries &Aquatic Resources

(Monthly Data Sheet)

| **Item** | **2004** | **2005** | **2004 Jan-Nov** | **2005 Jan-Nov** | **2006 Jan-Nov** |
|---|---|---|---|---|---|
| Fish Production (Mt) | | | | | |
| Marine sector | 253,190 | 130,400 | 233,320 | 112,500 | 192,810 |
| Inland&aquaculture | 33,180 | 32,830 | 31,000 | 30,070 | 29,480 |
| Total | 286,370 | 163,230 | 264,320 | 142,570 | 222,290 |

When fish consumption of households in Sri Lanka is considered, traditionally a majority of the population especially in urban areas is used to consume marine fish than freshwater fish. This is mainly due to the efficient marketing chain and network prevailing in the country, being an island nation. Sea fish is marketed by the Ceylon Fisheries Corporation, which has an island wide distribution network. Also private large-scale fish distributors also contribute in large measure to this distribution mechanism. As a result, sea fish is made easily available in the interior of the country within a matter of hours. Nearly all households in the coastal belt consume marine fish in the fresh form

However, due to escalation in marine fish prices during the past few decades, as a result of rising energy costs, the main marine fish varieties have become out of reach of the lower middleclass and the poor urban and rural households. Tables 9, 10, 11, 12, 13, 14 & 15 represent basic information on fish production. After fresh marine fish, dried fish is another product that is very popular among urban and rural households. Table 13 represents the total quantity of locally manufactured dry fish and imported quantities during the past 13 years up to 2004. The Table shows that there has been an upward trend in the total dry fish produced locally and what is imported to the country. In 2003, the total quantities produced locally and imported amounted to 21,840 Mt and 45,511 Mt respectively (9).

Table 9: **Basic Statistics of Marine Fisheries 2005** Source: Ministry of Fisheries and Aquatic Resources

| Fisheries District | Fishing Villages | Fishing Households | Active Fishers | Population / Households | Fish Landings |
|---|---|---|---|---|---|
| Batticaloa | 172 | 15,100 | 17,400 | 72,400 | 119 |
| Colombo | 27 | 2,500 | 2,900 | 10,900 | 17 |
| Negambo | 82 | 14,800 | 18,400 | 69,800 | 28 |
| Galle | 155 | 6,900 | 7,900 | 29,100 | 56 |
| Tangalle | 37 | 7,300 | 8,600 | 34,600 | 29 |
| Kalutara | 33 | 3,800 | 4,700 | 17,800 | 35 |
| Kalmunai | 258 | 14,600 | 14,900 | 69,800 | 64 |
| Matara | 86 | 7,200 | 8,600 | 34,200 | 32 |
| Puttalam | 108 | 13,200 | 16,300 | 59,700 | 59 |
| Chilaw | 40 | 9,300 | 11,200 | 44,200 | 58 |
| Trincomalee | 120 | 11,800 | 14,500 | 58,600 | 53 |
| Mullaitivu | 31 | 2,900 | 3,100 | 12,800 | 21 |
| Killinochchi | 40 | 3,500 | 3,900 | 14,200 | 19 |
| Jaffna | 107 | 16,800 | 18,100 | 77,200 | 102 |
| Mannar | 41 | 7,600 | 9,800 | 36,400 | 31 |
| **Total** | **1,337** | **137,300** | **160,300** | **641,700** | **723** |

Table 10: Fish Production by Fishing Sub – Sectors 1999-2005. (Source – Ministry of Fisheries & Aquatic Resources)

| Year | Total Fish Production (t) | Marine Fish Production | | Inland & Aquaculture Production (t) |
|---|---|---|---|---|
| | | Coastal (t) | Offshore& deep sea (t) | |
| 1990 | 183,990 | 134,130 | 11,670 | 38,190 |
| 1991 | 1,898,060 | 159,150 | 15,080 | 23,830 |
| 1992 | 206,170 | 163,170 | 22,000 | 21,000 |

| | | | | |
|---|---|---|---|---|
| 1993 | 220,900 | 169,900 | 33,000 | 18,000 |
| 1994 | 224,000 | 174,500 | 37,500 | 12,000 |
| 1995 | 237,500 | 159,250 | 60,000 | 18,250 |
| 1996 | 228,550 | 149,300 | 57,000 | 22,250 |
| 1997 | 242,000 | 152,750 | 62,000 | 27,250 |
| 1998 | 269,850 | 166,700 | 73,250 | 29,900 |
| 1999 | 279,900 | 171,950 | 76,500 | 31,450 |
| 2000 | 300,380 | 179,280 | 84,400 | 36,700 |
| 2001 | 284,760 | 167,530 | 87,360 | 29,870 |
| 2002 | 302,890 | 176,250 | 98,510 | 28,130 |
| 2003 | 284,960 | 163,850 | 90,830 | 30,280 |
| 2004 | 286,370 | 154,470 | 98,720 | 33,180 |
| 2005 | 163,230 | 63,690 | 66,710 | 32,830 |

Table 11**:** **Marine Sector Fish Production by Fisheries Districts 1999-2005**

| Fisheries District | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|
| Batticaloa | 10,900 | 9,860 | 11,450 | 15,140 | 22,240 | 16,160 | 7,650 |
| Chilaw | 24,260 | 25,650 | 23,960 | 19,900 | 13,570 | 14,220 | 9,360 |
| Colombo | 2,920 | 3,130 | 2,810 | 2,,980 | 1,990 | 1,640 | 560 |
| Galle | 24,980 | 27,830 | 26,760 | 15,060 | 20,870 | 17,,530 | 11,210 |
| Kalmunai | 8,960 | 9,120 | 10,650 | 17,750 | 21,380 | 19,790 | 7,940 |
| Kalutara | 29,970 | 33,140 | 32,110 | 29,470 | 21,700 | 20,690 | 11,560 |
| Matara | 34,450 | 35,480 | 34,410 | 34,000 | 28,430 | 17,990 | 17,090 |
| Negambo | 29,820 | 34,540 | 32,620 | 26,490 | 20,940 | 22,780 | 16,940 |
| Puttalam | 27,930 | 29,730 | 28,030 | 23,560 | 16,640 | 16,520 | 11,670 |
| Tangalle | 32,990 | 33,470 | 28,050 | 26,860 | 21,700 | 21,960 | 6,220 |
| Trincomalee | 14,770 | 13,540 | 14,790 | 18,980 | 15,030 | 17,540 | 6,790 |
| Mullaithivu | | | | 3,820 | 2,250 | 2,200 | 780 |
| Killinochchi | | | | 1,480 | 2,760 | 3,130 | 1,460 |
| Jaffna | | | | 12,340 | 28,550 | 33,980 | 12,790 |
| Mannar | | | | 16,930 | 16,630 | 17,060 | 8,380 |
| ** Northern Province | 6,500 | 8,190 | 9,250 | 34,570 | 50,190 | 56,370 | - |
| **Total** | 248,450 | 263,680 | 254,890 | 274,760 | 254,681 | 253,190 | 130,400 |

Source – Ministry of Fisheries & Aquatic Resources; ** Northern Province consists of Jaffan, Killinochchi, Mullaitivu, & Mannar Districts

Table 12: Marine Fish Production (t) by Major Varieties 1999- 2005

| Variety | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|
| Seer | 3,860 | 3,130 | 3,660 | 3,920 | 6,290 | 5,260 | 2,970 |
| Paraw | 9,780 | 10,450 | 9,950 | 10,760 | 14,940 | 13,580 | 5,950 |
| Balaya | 40,370 | 49,110 | 49,710 | 54,640 | 42,810 | 43,830 | 28,040 |
| Kelawalla | 28,320 | 29,320 | 30,910 | 38,430 | 27,620 | 32,870 | 17,030 |
| Other Blood Fish | 26,410 | 27,890 | 25,790 | 27,540 | 35,210 | 36,830 | 16,560 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Shark/Skate | 29,360 | 28,790 | 26,410 | 25,340 | 26,590 | 21,320 | 6,430 |
| Rock Fish | 12,450 | 14,910 | 14,490 | 16,320 | 19,980 | 17,540 | 10,570 |
| Shore Seine | 69,370 | 76,250 | 68,730 | 72,910 | 50,310 | 54,410 | 24,870 |
| Prawns | 7,680 | 7,540 | 7,360 | 9,820 | 10,190 | 9,730 | 4,680 |
| Lobsters | 950 | 1,150 | 2,340 | 2,340 | 2,530 | 1,590 | 240 |
| Others | 19,900 | 15,140 | 15,540 | 12,740 | 18,210 | 16,230 | 13,060 |
| **Total** | **248,450** | **263,680** | **254,890** | **274,760** | **254,680** | **253,190** | **130,400** |

Source – Ministry of Fisheries & Aquatic Resources

Table 13: Local Production and Imports of Dried Fish 1992 – 2005

| **Year** | **Local (t)** | **Imported (t)** | **Total (Mt)** |
|---|---|---|---|
| 1992 | 14,400 | 44,290 | 58,690 |
| 1993 | 15,500 | 64,750 | 80,250 |
| 1994 | 16,120 | 47,620 | 63,740 |
| 1995 | 12,000 | 44,798 | 56,798 |
| 1996 | 10,000 | 43,864 | 53,864 |
| 1997 | 12,000 | 48,782 | 60,782 |
| 1998 | 14,500 | 49,426 | 63,926 |
| 1999 | 18,450 | 45,312 | 63,762 |
| 2000 | 24,360 | 50,550 | 74,910 |
| 2001 | 17,640 | 45,280 | 62,920 |
| 2002 | 24,690 | 44,488 | 69,178 |
| 2003 | 21,840 | 45,511 | 67,351 |
| 2004 | 25,390 | 37,842 | 63,232 |
| 2005 | 7,560 | 44,608 | 52,168 |

Source – Ministry of Fisheries & Aquatic Resources

Table 14:Quantity and Value of Exports of Fish and Fishery Products 2000 – 2005; quantity in t; value in Rs. millions

| **Description** | **2000** | | **2001** | | **2002** | | **2003** | | **2004** | | **2005** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Val** |
| Prawns | 4855.0 | 5041.4 | 3941.0 | 4300.0 | 3368.0 | 3286.0 | 4467.7 | 4165.0 | 2462.5 | 2359.3 | 1800.0 | 1769.0 |
| Lobsters | 164.2 | 157.1 | 198.0 | 221.0 | 272.0 | 317.0 | 455.6 | 164.8 | 235.9 | 219.5 | 183.0 | 267.0 |
| Crabs | 554.5 | 154.2 | 677.0 | 203.0 | 1302.0 | 374.0 | 1106.4 | 320.0 | 1107.9 | 371.7 | 1012.0 | 363.0 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beche de Mer | 86.6 | 143.3 | 84.0 | 166.0 | 140.0 | 257.0 | 160.6 | 311.6 | 271.4 | 509.1 | 258.0 | 334.0 |
| Ornamental Fish | 1013.2 | 593.3 | 790.0 | 545.0 | 640.0 | 529.0 | 685.4 | 623.6 | | 745.2 | | 756.0 |
| Chank & Shells | 697.6 | 90.0 | 498.0 | 92.0 | 324.0 | 58.0 | 683.2 | 121.3 | 588.4 | 92.6 | 546.0 | 124.0 |
| Shark Fins | 118.8 | 305.2 | 85.0 | 242.0 | 83.0 | 215.0 | 82.8 | 336.0 | 110.4 | 342.9 | 74.0 | 165.0 |
| Molluscs | 14.6 | 14.1 | 25.0 | 13.0 | 55.0 | 37.0 | 108.8 | 66.5 | 241.7 | 96.2 | 300.0 | 98.0 |
| Fish Maws | 0.9 | 0.9 | 1.0 | 2.0 | 1.0 | 3.0 | 1.7 | 3.2 | 1.4 | 3.3 | 1.0 | 3.0 |
| Fish | 11873.2 | 3781.5 | 8997.0 | 3075.0 | 7724.0 | 2887.0 | 7562.7 | 3300.5 | 8017.2 | 4476.4 | 10960.0 | 6335.0 |
| Fish Others * | 1883.3 | 47.0 | 276.0 | 61.0 | 263.0 | 84.0 | 375.0 | 130.0 | 644.0 | 219 | 851.0 | 484.0 |
| **Total** | **19566.9** | **10328.0** | **15572.0** | **8920.0** | **14172.0** | **8047.0** | **15689.9** | **9542.5** | **13680.8** | **9435.2** | **15985.0** | **10698.0** |

Table 15:Quantity (t) and Value (Rs. Millions) of Imports of Fish and Fishery Products 2000 – 2005

| **Description** | **2000** | | **2001** | | **2002** | | **2003** | | **2004** | | **2005** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Value** | **Qty** | **Value** |
| Maldive Fish | 4316.6 | 655.6 | 5569.0 | 1003.0 | 6133.0 | 996.0 | 5928.2 | 877.3 | 5241.2 | 788.0 | 5542.0 | 832.0 |
| Dried Fish | 50550.2 | 2979.4 | 45280.0 | 3262.0 | 44480.0 | 2930.0 | 45511.8 | 2853.6 | 37842.1 | 2430.5 | 44608.0 | 2916.0 |
| Canned Fish | 21893.5 | 1469.9 | 20331.0 | 1473.0 | 20166.0 | 1740.0 | 18092.7 | 1706.5 | 18071.1 | 1764.5 | 20229.0 | 2304.0 |
| Others | 578.5 | 26.7 | 407.0 | 29.0 | 749.0 | 81.0 | 5586.5 | 125.3 | 1534.8 | 317.1 | 1293.0 | 353.0 |
| **Total** | **77338.8** | **5131.7** | **71587.0** | **5767.0** | **71536.0** | **5747.0** | **75199.2** | **5562.7** | **62689.2** | **5300.1** | **71672.0** | **6405.0** |

Tables 14 & 15 Source – Ministry of Fisheries & Aquatic Resources. Department of Sri Lanka Customs when the per capita consumption of fresh and dried fish of a household is considered the ratio is 3:1 going by Table 7. The share of average household expenditure for fresh and dried fish consumption for the three sectors is represented below.

Table 16: The share of average household expenditure for fresh and dried fish consumption

| Item | Overall Rs. | Share % | Urban Rs. | Share % | Rural Rs. | Share% | Estate Rs. | Share % |
|---|---|---|---|---|---|---|---|---|
| Fish (fresh) | 647 | 69.05 | 965 | 81.29 | 619 | 66.77 | 215 | 53.75 |
| Fish (dried) | 290 | 30.94 | 222 | 18.70 | 308 | 33.22 | 185 | 46.25 |
| Total | 937 | | 1187 | | 927 | | 400 | |

Another important product imported to the country is canned fish. Table 15 illustrates the quantity and value of canned fish imports to Sri Lanka from the year 2000 to 2004. There has been no significant increase of canned fish imports during these years. However, it would be interesting to see the quantity imported during 2005 due to effects of the Tsunami.

In the year 2004, the share of dried fish local production and imports was 16.52% of the total fish production consumed locally, while the share of imported canned fish products was 6.57%. Of the approximately 17% of dried fish locally produced and imported nearly 46% is consumed within the estate sector and another 33% within the rural households.

The contribution of inland fish production mainly from capture and culture based fisheries is approximately 12% of the total fish production, compared to the contribution from coastal and offshore/deep sea, which was 54% and 34% respectively. Due to high unaffordable prices of marine fish, rural lower middle class poor households consume more freshwater fish and dried fish in the inland dry zones of the country. The species consumed comprises tilapia as the major species followed by Indian and Chinese carps. About 90% of inland freshwater fish produced is consumed within the area of production, both in rural and urban households. The average per capita consumption/availability varied between 3.1 and 3.6kg in districts of the North Central, Central, Uva and Sabaragamuwa Provinces as given in Table 17, with the maximum per capita consumption/availability being reported from the Anuradhapura district in the north-central province, amounting to 8.7kg, followed by Polonnaruwa district which amounted to 7.1kg (10). The consumption of freshwater fish (even in the urban freshwater fish producing areas), canned and dried fish, increased due to rejection of marine fish in the immediate aftermath of the Tsunami. Less than 1% of freshwater fish especially tilapia, find its way to the suburbs of Colombo.

The per capita consumption for Sri Lanka based on local fish production without accounting imported dried and canned fish was14.31kg in 2004 and decreased to 6.1kg in 2005 with the effects of the Tsunami. The Table 17 below, illustrates the per capita consumption of marine and freshwater fish over the last 4 years.

Table 17: Per Capita Consumption (kg) of Marine and Freshwater fish

| **Year** | **Local fish Production (t)** | | **Per Caput Consumption** | |
|---|---|---|---|---|
| | **Marine** | **Freshwater** | **Marine** | **Freshwater** |
| 2002 | 267,036 | 28,130 | 13.9 * | 3.1** |
| 2003 | 247,118 | 30,280 | 12.8 * | 3.3** |
| 2004 | 239,510 | 33,180 | 12.5 * | 3.6** |
| 2005 | 119,440 | 32,830 | 6.1 * | 3.5** |

Sources**:** Department of Census & Statistic; Central Bank of Sri Lanka - Annual Report 2005; **NAQDA – Data Sheet;** *Computed with total Sri Lanka population; **Computed with population in freshwater fish producing districts

Fisheries and Aquaculture in relation to GDP and its Past Trends

The Marine Fisheries Sector:

There are three main sub-sectors, namely Coastal, Offshore and Deep sea Fisheries. The coastal fishery takes place within the continental shelf and undertaken by fishing craft in single day operations. This sub-sector continues to be dominant in terms of contribution to production and employment in the sector. The fishing fleet represent around 90% of the entire fishing fleet of the country and estimated 80,000 fishers are directly involved in fishing in this sub-sector (1).

The Offshore/Deep Sea/High Seas Fisheries, take place outside the continental shelf and beyond, extending up to the edge of the Exclusive Economic Zone (EEZ) and even in the high seas, operated by multi-day boats. This is a fast growing sub-sector. In 2004, this sub-sector contributed 34% to the total fish production in the country. The rapid expansion of the multi day fleet, which was 1581 in 2004, has been primarily responsible for the growth of this sub-sector.

Table 18: Fish Production by Sub-Sectors 2004 (Source: Ministry of Fisheries & Aquatic Resources)

| Sub sector | Production (Mt) | % |
|---|---|---|
| Coastal | 154,470 | 54 |
| Offshore & Deep sea | 98,720 | 34 |
| Inland Fisheries & Aquaculture | 33,180 | 12 |
| Total | 286,370 | 100 |

Inland Fisheries & Aquaculture Sector

Inland fisheries and aquaculture development commenced in the mid 70's through to late 80's as a major national program. Although the government's attempts during this period was successful in developing the capture fishery in perennial reservoirs and culture based fisheries in seasonal tanks on a major scale, its programs to encourage pond fish culture in especially the freshwater sub sector, failed to produce significant results. The main reasons for this could be cited as follows. 1) Sri Lanka did not have a tradition for freshwater or brackish water fish aquaculture for production of food fish and as a means of livelihood development, unlike her South and South East Asian neighbors, at least not until the early and mid eighties, 2) availability of sea fish through out the country in a matter of hours and 3) low prices offered for freshwater fish in the local market, making freshwater fish aquaculture a non-starter economically.

However, capture fisheries from perennial reservoirs and culture-based fisheries in seasonal tanks developed rapidly between the mid 70's to 1990 and as a result the inland fish production too increased from a mere 8000 Mt in 1970 to 39,900 Mt by 1990. This was a result of the very ambitious programs implemented during this period by the then Inland Fisheries Division of the Ministry of Fisheries.

With the ceasing of government patronage for inland fisheries and aquaculture in 1990, all programs of the Division came to a grinding halt and the inland fish production dropped to 12,000 Mt by the year 1995. With the reinstatement of government patronage to inland fisheries in 1995, the former activities recommenced. In 1998, the National Aquaculture Development Authority was established under an Act of Parliament to continue with the programs implemented by the former Inland Fisheries Division of the Ministry of Fisheries & Aquatic Resources.

*Development of Coastal Aquaculture and the Present Position*

Unlike freshwater aquaculture, in the early 1980s, a number of local entrepreneurs and a few multinational companies embarked on culture of Peneaus monodon (black tiger shrimp) in ponds along the North Western coastal belt from Madampe to Puttalam responding to the initiatives by the government to develop shrimp farming for the export trade. The shrimp aquaculture industry in Sri Lanka originally commenced in Batticaloa in the eastern coast in the late 1970's and finally concentrated in the northwestern coastal belt covering a farm area of more than 4,500 ha. This industry also triggered the development of about 120 hatcheries catering to the post larval needs of the industry. Of the total developed area, grow-out culture ponds occupied an area of around 3,000 ha of the total 1,344 farms. In Batticaloa District, where shrimp farming first began and abandoned due to civil unrest, farming activities recommenced in recent years. Over 60 small-scale farms with an average farm extent of 1-2 ha were in operation by the end of 2002, with a total pond area of 155 ha. However, during the recent Tsunami that swept the North, NorthEastern and Southern coasts of Sri Lanka, most if not all shrimp farms on the eastern coast were affected/destroyed.

Shrimp farming has been the most lucrative commercial aquaculture activity in Sri Lanka since it commenced in the mid eighties. The industry recorded its peak economic performances in the year 2000 (Table 19), earning Rs. 5041 Mn worth of foreign exchange (Fig ). However, the quantity of processed (headless) shrimp exported in the year 2004, was 2462 MT earning a total export value of Rs.2359 Mn. (Ministry of Fisheries and Aquatic Resources, 2005). This has been as a result of the advent of 'White Spot' viral disease, which sprang up intermittently from 1996 onwards.

However, up to the year 2003, since there was inadequate monitoring and regulation of the industry, uncontrolled farming practices utilizing substandard culture techniques and post larvae, especially by small scale unauthorized shrimp farmers, brought about an unprecedented escalation of the 'White Spot' disease resulting in a near total collapse of the industry in 2004.

With the intervention of NAQDA and the measures put in place and being now implemented, the disease situation has been brought under control and the industry is now on the road to complete recovery. It is expected that by the end of 2006, the export production would increase to over 2000 Mts.

Table 19: Shrimp Production for Exports

| Year | Production (Mt) | Value (Rs.Mn) |
|---|---|---|
| 1996 | 3,155 | 2,365 |
| 2000 | 4,855 | 5,041 |
| 2001 | 3,941 | 4,300 |
| 2002 | 3,368 | 3,286 |
| 2003 | 4,468 | 4,165 |

| | | |
|---|---|---|
| 2004 | 2,462 | 2,359 |
| 2005 | 1,800 | 1,769 |

*Ornamental Fish & Aquatic Plants Production Sub Sector*

The ornamental fish culture industry is wide spread in the island, while the breeders and exporters are mainly limited to Colombo. Grow out systems in the ornamental fish culture industry are cement cubicles, glass aquaria and earthen ponds. The breeders practice simple natural spawning techniques to breed freshwater ornamental fish. The commonly used supplemental feeds in the industry are farmer-made aqua feeds, shrimp feeds and poultry feeds.

The marine ornamental fish export sector is totally dependent on the wild stocks; due to lack of breeding technology and currently over 200 marine species belonging to 40 families are exported. Increased harvesting pressure on marine ornamental wild fish stocks has brought about a depletion of several wild fish populations. As a result, the government of Sri Lanka has prohibited or restricted certain marine as well as wild caught freshwater fish species from export.

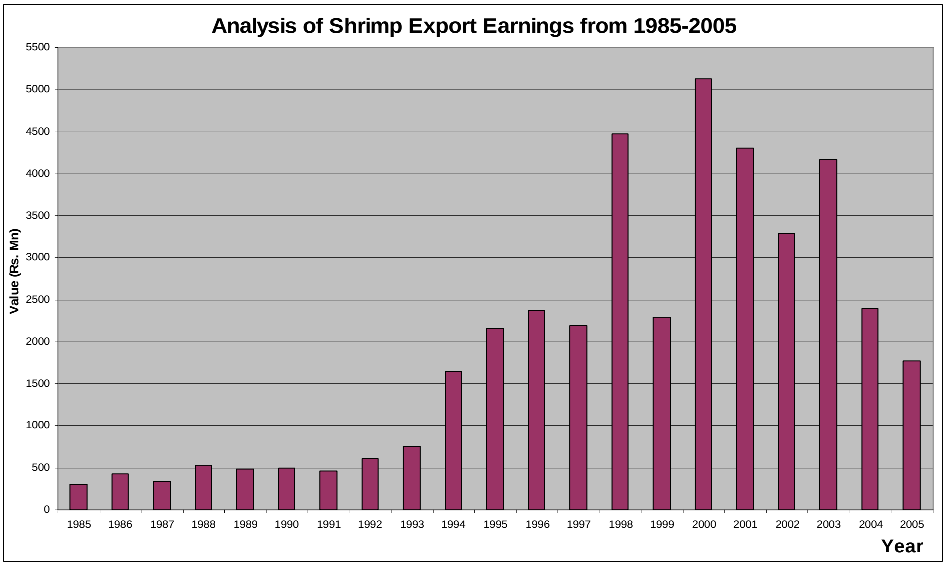
Sri Lanka exports ornamental fish to more than 18 destinations. The main 10 export markets, based on the value of ornamental fish exported from Sri Lanka are: Germany, France, The United Kingdom, Belgium, Netherlands, Spain, Switzerland, Japan, USA and Italy. According to the Department of Customs statistics, there are 66 large-scale and small-scale ornamental fish exporters in Sri Lanka. The total exports of ornamental fish (marine and freshwater) and aquatic plants amounted to 756 Mn in 2005 (Table 14). This increased to Rs. 889 Mn in 2006.

Fisheries (marine and inland fisheries) production in relation to GDP and GNP during the 10 years from 1996 to 2005 is represented in Table 20. The contribution to GDP varied between 2.7% in 1996 and 1.03% in 2005. The lower value in 2005 was an effect of the Tsunami in December 2004. Compared to the agriculture sector, where the contribution to GDP varied between 14.31 (2004) and 17.62 (1996), the fisheries sector contribution was rather marginal, which demonstrated the significant role played by the agriculture sector in the economy of Sri Lanka.

Table 20: Fish Production in relation to GDP and GNP (1996-2005) Compared with Agriculture Production (a: provisional)

| Sector | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 (a) | 2005 (a) |
|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 122,594 | 138999 | 153335 | 163481 | 171878 | 199584 | 232853 | 238240 | 257734 | 304,429 |
| Fisheries | 18,763 | 21,413 | 23661 | 25838 | 29386 | 31,144 | 34421 | 34442 | 33812 | 21577 |
| GDP | 695,934 | 803698 | 912839 | 994,730 | 1125259 | 1245599 | 1,403,283 | 1562737 | 1800750 | 2098323 |
| GNP | 684,676 | 794289 | 901283 | 976899 | 1102177 | 1221769 | 1379113 | 1546202 | 1780062 | 2068273 |
| Contribution to GDP % (Agriculture) | 17.62 | 17.29 | 16.80 | 16.43 | 15.27 | 16.02 | 16.59 | 15.25 | 14.31 | 14.51 |
| Contribution to GNP % (Agriculture) | 17.91 | 17.50 | 17.01 | 16.73 | 15.59 | 16.34 | 16.88 | 15.41 | 14.48 | 14.72 |
| Contribution to GDP % (Fisheries) | 2.70 | 2.66 | 2.60 | 2.59 | 2.61 | 2.50 | 2.45 | 2.20 | 1.88 | 1.03 |
| Contribution to GNP % (Fisheries) | 2.74 | 2.70 | 2.62 | 2.64 | 2.67 | 2.55 | 2.50 | 2.23 | 1.90 | 1.04 |

Aquaculture Production Trends




Early attempts to develop aquaculture of fresh water fish failed and as a result have not come up to levels in existence in other countries in the South East Asian region. The main reason attributed to this has been a lack of practical tradition and economic non-viability of fresh water aquaculture operations. However, the first reason mentioned above (lack of practical tradition), failed to hold water with the massive growth observed in the development of shrimp farming in Sri Lanka between 1983 and 1995. This simply goes to show that, if the economic benefits are higher than the interest earned from bank deposits (in shrimp farming at the early stages, the Internal Rate of Return (IRR) was over 45%), investors with whatever religious beliefs and cultures would embark on such ventures whether or not such ventures were traditionally practiced.

Aquaculture activities in Sri Lanka could be categorized as follows;

- Aquaculture of shrimps/prawns
- Aquaculture of freshwater fish and other fin fish
- Mud Crab Fattening in Cages
- Culture-Based Fisheries in Seasonal & Minor Perennial Tanks
- Aquaculture of ornamental fish
- Aquaculture of Rearing fry to fingerlings

Aquaculture of Shrimps/Prawns

Shrimp farming has been the most lucrative aquaculture venture not only in Sri Lanka, but all over the world. With the advent of WSSV in 1996 and again in 2003/4 period, the industry collapsed. However, by adopting certain control measures, by NAQDA, the disease situation has been brought under control and the production stabilized. The trend in shrimp production for exports from 1985 to 2006 is represented in Fig 3. NAQDA envisages that this export production would increase to 3500Mt tons by end 2007.

Aquaculture of Freshwater Fish & other Fin Fish

Aquaculture of freshwater fish namely, tilapias, Indian and Chinese carps is being promoted by NAQDA extension unit and we have data of aquaculture activities being carried out on a very minor scale. During the last 2 decades, the prices of freshwater fish have also increased and with home made supplementary diets as advised by NAQDA extension staff, the rural folk have commenced pond fish culture as an alternate source of income to supplement income from agriculture farming practices. The data obtained from areas where aquaculture of freshwater fish is taking place is presented in Table 21. According to the data, 98 Mt of fish have been harvested in the producing districts.

Apart from culture of freshwater fish, a new development is seen in the North Western Province of the country, where shrimp farmers have commenced milkfish culture for the Tuna bait fishery. This is still in its early stages and no significant data is available at present for reporting. Details of milk fish culture for tuna bait and for consumption is presented in Table 22.

Another aquaculture activity, which is still in its early stages, is cage culture of Sea Bass in the Negombo lagoon under the Coastal Resources Management Project. With the recent Tsunami, the Negombo lagoon depth had increased and Sea Bass cage culture is being done in the cleared deep areas of the lagoon. Annex 3, illustrates some of the cage culture activities that are taking place in the lagoon.

Mud Crab Fattening in Cages

Mud crab (Scylla serrata) or lagoon crab fattening is another aquaculture activity currently in operation in abandoned shrimp ponds in the Puttalam District and in the Negombo and Kalpitiya lagoons in cages. This activity has been in operation for some time mainly, for export purposes. Illustrations of such operations are presented in Annex1.

Culture-Based Fisheries in Seasonal & Minor Perennial Tanks

As mentioned in earlier paragraphs, capture fisheries from major and medium reservoirs and culture based fisheries in minor perennial tanks and seasonal tanks, have been the mainstay in freshwater fish production from the vast area of inland water bodies in Sri Lanka. The freshwater fish production from 1970 to 2006 is presented in Table 23. The decline from 39,000 Mt in 1990 to 12, 000 Mt in 1995 has been due to the ceasing of Government patronage to inland fisheries and aquaculture by the then administration (Fig 4). An activity, which has been given prominence in the ADB, funded ARDQI Project, is culture based fisheries in minor perennial tanks and seasonal tanks in the interior of the country. Culture based fisheries in seasonal tanks first commenced between 1980 to 1990 period. Yields of between 750 and 1250kg per ha have been reported. It is envisaged that, by the year 2009, the yield from seasonal tanks and minor perennial tanks would increase

However, with the re-instatement of Government patronage in 1995 and the establishment of NAQDA by an Act of Parliament in 1998, all efforts were directed at recommencing the programs implemented prior to 1990. With the assistance provided by the Aquaculture Resource Development & Quality Improvement Project (ARDQIP) funded by the Asian Development Bank (ADB), NAQDA has been able to increase the production of freshwater fish from 12,000 Mt to 34,000 Mt by 2006.

Table 21 Food Fish Production in Ponds 2005-2006

| District | Year | No of Ponds | Total Area $m^2$ | Total Area ha | Date of stocking | Stocking Density ($Fin/m^2$) | No of FL Stocked | Harvest (Kg) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Ampara | - | 15 | 69,280 | 6.9280 | - | 01 | 69,280 | - | To be harvested |
| Anuradhapura | - | 25 | 43,450 | 4.3450 | | 02 | 88,365 | | To be harvested |
| | | 06 | 10,500 | 1.0500 | - | | | - | |
| Total | | 31 | 53,950 | 5.3950 | | | 88,365 | | |
| Batticaloa | - | 02 | 7,500 | 0.7500 | - | 01 | 7,100 | 1,700 | - |
| Badulla | - | | | | - | | | - | - |
| Colombo | - | 03 | 250 | 0.0250 | 2006 March | 12 | 3,000 | 335 | One pond damaged |
| | | 08 | 5,905 | 0.5905 | 2006 Mar – Aug | 07 | 41,550 | | |
| | | 02 | 100 | 0.0100 | 2006 May | 05 | 500 | | |
| | | 01 | 100 | 0.0100 | 2006 August | 05 | 500 | | |
| | | 02 | 700 | 0.0700 | 2006 February | | | | |
| Total | | 16 | 7,055 | 0.7055 | | 06 | 45,550 | 335 | |
| Gampaha | - | 15 | 49,250 | 4.9250 | - | 02 | 94,310 | - | - |
| Galle | - | 03 | 750 | 0.0750 | | 02 | 1,760 | 389 | To be harvested |
| | | 09 | 2,475 | 0.2475 | | 03 | 6,830 | | |
| | | 24 | 7,802 | 0.7802 | - | 02 | 19,450 | | |
| | | 13 | 3,354 | 0.3354 | | 03 | 9,150 | | To be harvested |
| Total | | 49 | 14,381 | 1.4381 | | 02 | 37,190 | 389 | |
| Hambantota | 2005 | 36 | 39,620 | 3.9620 | | 02 | 82,470 | 7,523 | |
| | 2006 | 24 | 53,375 | 5.3375 | - | 01 | 61,710 | | To be harvested |
| Total | | 60 | 92,995 | 9.2995 | | 02 | 144,180 | 7,523 | |
| Kalutara | - | - | - | - | - | - | - | - | - |
| Kegalle | - | - | - | - | - | - | - | - | - |

| District | Year | No of Ponds | Total Area $m^2$ | Total Area ha | Date of stocking | Stocking Density (Fin/$m^2$) | No of FL Stocked | Harvest (Kg) | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| Kandy | - | 06 | 1,520 | 0.1520 | | 1 | 1,450 | | To be harvested |
| | | 02 | 750 | 0.0750 | - | 6 | 4,550 | 105 | |
| | | 06 | 5,250 | 0.5250 | | 1 | 6,000 | 996 | |
| | | 14 | 7,520 | 0.7520 | | 2 | 12,000 | 1,101 | |
| Kurunegala | - | 176 | 16,255,400 | 1625.54 | - | 0.02 | 248,296 | 2,399 | - |
| Matale | - | 48 | 13,680 | 1.3680 | - | 2 | 33,110 | 3,718 | - |
| Matara | 2006 | 08 | 4,850 | 0.4850 | | 7 | 32,460 | | To be harvested |
| | | 25 | 4,500 | 0.4500 | - | | | 4,547 | |
| Total | | 33 | 9,350 | 0.9350 | | 7 | 32,460 | 4,547 | |
| Monaragala | 2005 | 53 | 71,850 | 7.1850 | | 1 | 53,350 | | To be harvested |
| | 2006 | 27 | 126,700 | 12.6700 | - | 0.3 | 37,165 | | |
| Total | | 80 | 198,550 | 19.855 | | 1 | 90,515 | | |
| Nuwara Eliya | - | 70 | 32,000 | 3.2000 | - | 1 | 40,000 | 1,433 | - |
| Polonnaruwa | - | 04 | 12,000 | 1.2000 | - | | | | - |
| Puttalam | 2005 | 41 | 145,000 | 14.5000 | | 1 | 137,633 | 33,725 | |
| | 2006 | 197 | 1,085,000 | 108.5000 | - | 0.3 | 341,965 | 42,109 | - |
| Total | | 238 | 1,230,000 | 123 | | 0.4 | 479,598 | 75,834 | |
| Ratnapura | - | - | - | - | - | - | - | - | - |
| Trincomalee | - | - | - | - | - | - | - | - | - |
| Vavuniya | - | - | - | - | - | - | - | - | - |
| **Total** | | **851** | **18,052,911** | **1,805** | **-** | **0.08** | **1,421,594** | **98,989** | **-** |

Table 22: Milk Fish Farming- Puttalam District 2006

| **No of Ponds** | **Area (Ha)** | **Number stocked** | **Date** | **Harvest** | |
|---|---|---|---|---|---|
| | | | | **Food (Kg)** | **Bait (Kg)** |
| 04 | 2 | 20,000 | 10/04/2006 | - | - |
| 06 | 3 | 11,000 | 17/05/2006 | - | - |
| 03 | 1.5 | 15,000 | 02/05/2006 | 450 | - |
| 01 | 1.5 | 5,000 | 10/05/2006 | - | - |
| 02 | 1 | 9,500 | 20/04/2006 | 930 | - |
| 02 | 1 | 20,000 | 04/2006 | 2,350 | - |
| 02 | 1 | 10,000 | 04/05/2006 | 1,000 | - |
| 02 | 1 | 20,000 | 14/07/2006 | - | 1,600 |
| | | | | | 1,250 |
| 04 | 2 | 28,500 | 02/07/2006 | - | 15,000 |
| 02 | 1 | 10,000 | 30/05/2006 | - | - |
| 01 | 0.5 | 5,000 | 15/06/2006 | - | - |
| 01 | 0.5 | 6,000 | 12/04/2006 | - | - |
| 01 | 1 | 10,000 | 08/2006 | - | - |
| 02 | 0.75 | 20,000 | 30/07/2006 | 800 | - |
| 01 | 1 | 3,000 | 10/01/2006 | 150 | - |
| 02 | 2 | 20,000 | 01/2006 | 2,200 | - |
| 04 | 2 | 28,000 | 02/07/2006 | - | 12,250 |
| 02 | 2 | 20,000 | 10/07/2006 | - | - |
| 01 | 0.5 | 10,000 | 20/08/2006 | - | - |
| 04 | 2 | 20,000 | 12/01/2006 | - | - |
| 01 | 0.5 | 2,000 | 02/11/206 | - | - |
| 01 | 0.5 | 1,500 | 10/10/2006 | - | - |

| No of Ponds | Total Area (Ha) | Number stocked | Date | Harvest | |
|---|---|---|---|---|---|
| | | | | Food (Kg) | Bait (Kg) |
| 02 | 1 | 2,000 | 05/12/2006 | - | - |
| 01 | 0.25 | 3,000 | 12/11/2006 | - | - |
| 09<br><br>04 | 5<br><br>5 | 85,000<br><br>35,000 | 20/01/2006<br><br>04/01/2006 | <br><br>12,000 | - |
| 04<br><br>18 | 02<br><br>08 | 86,000<br><br>500,000<br>1,000,000<br>1,000,000 | 06/05/2006<br><br>06/2006<br>-<br>12/2006 | <br><br>- | 795<br><br>100,000<br>100,000<br>100,000 |
| 08 | 05 | 80,000<br>40,000 | 04/2006<br>08/2006 | - | - |
| 01 | 01 | 2,800 | 05/01/2006 | - | - |
| 02 | 01 | 15,000 | 09/01/2006 | - | - |
| **96** | **56.5** | **3,143,300** | | **19,800** | **390,885** |

Table 23**: Inland Fish production from 1970 to 2005**

| Year | Fish Production Mt |
|---|---|
| 1970 | 8,300 |
| 1980 | 20,200 |
| 1990 | 39,000 |
| 1991-1994 | The Dark Period |
| 1994 | 12,000 |
| 1995 | 18,250 |
| 1996 | 22,250 |
| 1997 | 27,250 |
| 1998 | 29,900 |
| 1999 | 31,450 |
| 2000 | 36,700 |
| 2001 | 29,870 |
| 2002 | 28,130 |
| 2003 | 30,280 |
| 2004 | 33,180 |
| 2005 | 32,830 |

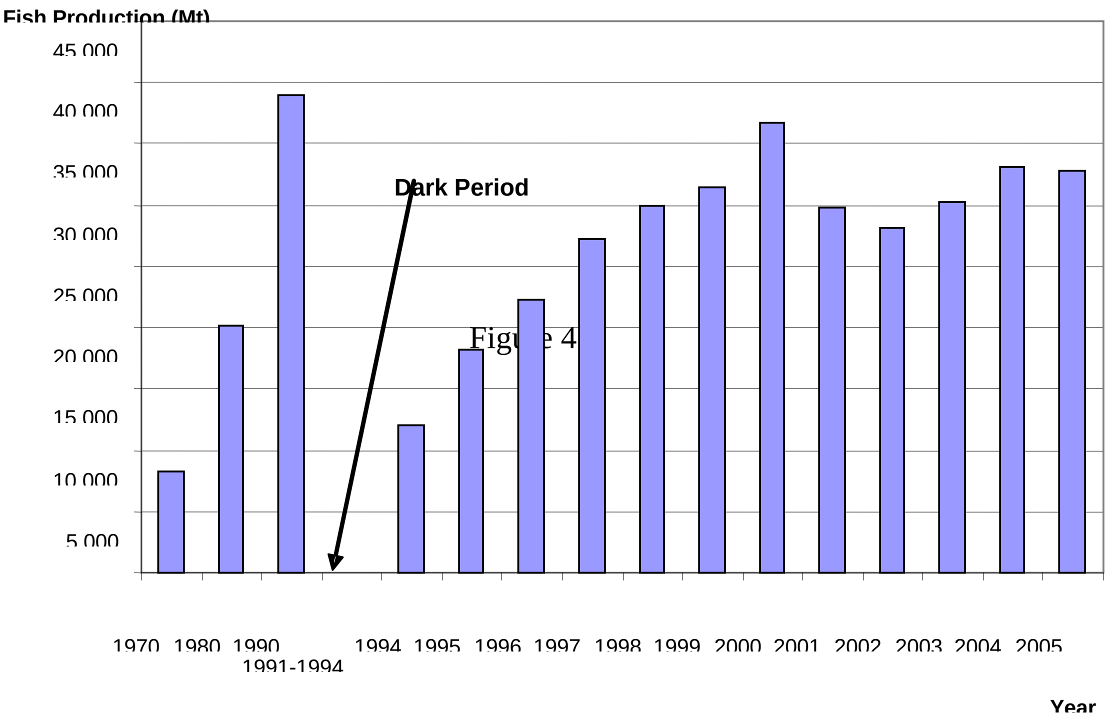



Figure 4

Table 24: Summary of the projected fish production from sub-sectors (2007 – 2016) – Quantity tons

| Year | Coastal | Offshore/ High Seas | Inland Fish & Aquaculture | Total Fish Production |
|---|---|---|---|---|
| 2004 | 154,470 | 98,720 | 33,180 | 286,370 |
| 2007 | 180,766 | 80,136 | 39,500 | 300,402 |
| 2012 | 234,183 | 161,200 | 55,399 | 450,782 |
| 2016 | 240,983 | 194,200 | 72,614 | 507,797 |

The targeted freshwater fish/shrimp production is expected to be obtained as follows;

- Increase in fish production by capture fishery is planned through a) introduction of efficient management measures of the fishery by Fisheries Societies, b) increase in Indian carp production through comprehensive stocking programs (already there is evidence of Indian carp natural breeding in certain major perennial reservoirs), c) efficient collection of catch statistics from perennial reservoirs, d) identification and introduction of co-management to perennial tanks, especially minor perennial tanks from which fish production statistics has not been collected or reported so far (at present, fish production is reported only from about 30% of the total area of inland water bodies).
- Increase in production of Indian and Chinese carps in minor perennial and seasonal tanks through culture based fisheries.
- Increase in freshwater fish production through aquaculture by promoting mono-sex culture of tilapia and freshwater prawns (Macrobrachium rosenbergii), mainly for exports with the assistance of Small & Medium Enterprises (SME) Bank and promoting carp culture at the village level.
- Increase in production of shrimps by opening new unutilized areas in the Eastern coastal belt in Sri Lanka. Already a Zonal Plan for the Batticaloa and Amparai districts have been prepared to identify shrimp farming areas for development.

Aquaculture of Fry to Fingerling Rearing

This aquaculture activity was commenced under the ARDQIP funded by the ADB. Under the project already 16 mini-nurseries have been established to grow out fry obtained from NAQDA Aquaculture Development Centers (AQDCs) to fingerlings to be sold to Fisheries Societies. In Anuradhapura district alone there are over 100 private pond operators, who earn between Rs. 75,000.00 to Rs. 125,000.00 per culture cycle of one and a half months (Illustrations are presented in Annex 2).

Aquaculture of Ornamental Fish

In the freshwater ornamental fish aquaculture sector, NAQDA envisages to increase production for exports by introducing brood stock of new varieties of both endemic and exotic fish to breeders and out growers, thereby increasing the product range for exports, which is lacking in Sri Lanka at present. The main aim of NAQDA is to increase Sri Lanka's share in world exports up to 15% within the next 10 year period.

### ***Major Aquaculture Initiatives (1980 to 2005)***

As mentioned earlier, early attempts at popularizing freshwater pond fish culture failed due to non-economic viability of such activities. Most of the ponds constructed by rural folk due to the attraction created by the government by introducing a subsidy for the construction of mud ponds to promote freshwater fish culture, were used by the owners to culture ornamental fish for exports. In 1978, FAO fielded a Mission to explore the possibilities of increasing freshwater fish production in Sri Lanka. The following projects were recommended;

<u>Culture Based Fisheries in Seasonal Tanks</u>

The idea of making use of seasonal and minor perennial tanks for fish culture with community participation was first mooted in the late 60's, by A.S Mendis, a former Research Officer attached to the Research Division of the Ministry of Fisheries & Aquatic Resources. Subsequently, this became a recommendation of the FAO/ADB joint Mission in the late 70's. The first project was implemented during 1980 to 1990 period.

<u>Aquaculture of Penaed Shrimp</u>

Another project recommended by the same mission was the establishment of a Shrimp Hatchery and Demonstration Farm in the Puttalam district in the North Western Province of Sri Lanka. The main objective was to demonstrate the technology to rural folk to commence shrimp farming for export (1985 to 1990).

<u>Cage Culture in Inland Reservoirs & Pen Culture in Brackish water</u>

Lagoons: A project to establish the technical and economic feasibility of cage culture in freshwater reservoirs and pen culture in lagoons was carried out between 1982 to 1989 period, with the financial assistance of the International Development Research Centre, Canada.

Second Project on Culture Based Fisheries in Seasonal Tanks (1997-2004) & the Project on Reservoir Fisheries Management: Two foreign funded projects were implemented during 1997 to 2004 period vis-à-vis, Culture Based Fisheries in Seasonal Reservoirs funded by, the Australian Centre for International Agriculture Research (ACIAR), jointly by the University of Kelaniya, Sri Lanka and NAQDA and the project on Reservoir Fisheries Management implemented by the GTZ. Both projects dealt with culture based fisheries in seasonal tanks in the arid and semi-arid zones in Sri Lanka (11).

Aquaculture Resource Development & Quality Improvement Project: This project was initiated in 1998 and project implementation commenced in the year 2003. The major components of this project are 1) increasing freshwater fish production from major and medium perennial reservoirs, 3) establishment of mini-nurseries for fish seed production with community participation, 4) implementation of micro credit schemes to promote aquaculture and 5) demonstrate the technical and economic feasibility of aquaculture operations with private sector involvement through public/private sector partnerships.

A Critical Evaluation of the Successes/Failures of Implemented Projects: Of the afore mentioned projects the two most successful ones are 1) Culture based fisheries in seasonal tanks and 2) Shrimp farming. Both projects have been successful mainly due to their economic viability. In culture-based fisheries in seasonal and minor perennial tanks, the only financial input is the cost incurred in the purchase of fingerlings for stocking. The fish thrives and grow on the natural productivity of the tanks caused by decomposition of dung of grazing cattle during the drought and also through the flow of nutrients from catchment areas during the rainy season.

Culture Based Fisheries in Seasonal and Minor Perennial Tanks: The most successful project ever to be implemented is the culture-based fisheries in seasonal tanks in Sri Lanka. The early work done in this regard prior to 1990 with ADB funding was later complemented by a systematic and scientific research study conducted by the Kelaniya University of Sri Lanka in collaboration with NAQDA and funded by a grant by the ACIAR in two stages (1998 to 2005). At present, NAQDA is continuing to implement this activity making use of the information obtained from the ACIAR study, under the ARDQIP funded by the ADB. Under this project, culture based fisheries has been extended to the minor perennial tanks as well.

Although culture based fisheries in seasonal tanks is very successful, there are conflicts between the end users, mainly the agriculture farmers and the fishers. The conflicts arise from water usage. The seasonal tanks and the minor perennial tanks come under the jurisdiction of the Department of Agrarian Services and the water usage is regulated under the Agrarian Services Act, the primary objective of which is to provide water for agriculture activities. However, over the years, these issues have been discussed with the intervention of the Ministry of Fisheries, NAQDA, the Ministry of Agriculture & Livestock and the Department of Agrarian Services and consensus has been reached. Further the field officers of the Department of Agrarian Services have been trained from time to time, on technical aspects of culture based fisheries and on the economic gains for members of Agrarian Societies who mange the activities of the seasonal tanks.

Consensus reached between policy makers on most occasions fail to trickle down to the stakeholders at the village level and in some Agrarian Societies conflicts still arise between the members of the societies and the fishers. Dialogues are still taking place among the stakeholders and officials to resolve these issues. A recent development is the appointment of the Director General of Agrarian Services as a member to the Board of Directors of NAQDA.

NAQDA believes that the best way to resolve such conflicts is to integrate the activities of the Department of Agrarian Services with culture based fisheries by including this activity as a function of the Agrarian Services Act. This would give the necessary impetus to the field officers of the Department, to devise ways of managing the water resources of seasonal tanks to benefit both agriculture and aquaculture activities. NAQDA’s future role would be to conduct training programs on technical and economic aspects of culture based fisheries to stakeholders and to ensure that fingerlings supply to the seasonal tanks are made readily available with the onset of the rainy season by coordinating with the community managed mini-nurseries.

Shrimp Farming: It is needless to mention the benefits the countries all over the world and the stakeholders have gained through shrimp aquaculture. Even today this industry stands alone in generating maximum economic gains to farmers. The key word is sustainable development and through various control measures adopted by NAQDA and through introduction of Best Management Practices (BMP’s) to farmers, it is believed that significant increases in production could be achieved in the foreseeable future.

Cage/Pen Culture Project: The cage culture project funded by the International Development Research Centre, Canada (IDRC), commenced in 1982 and ended in 1989. During this period, research work on species, stocking densities and feed compositions in two phases was carried out and the economic feasibility of cage/pen culture in Sri Lankan reservoirs and lagoons was demonstrated. A third phase was planned in 1989 to extend the methodology of cage/pen culture to the rural fishers. However, a policy decision by the then government to cease Government patronage to inland fisheries development and aquaculture, put paid to the plans of the inland Fisheries Division (IFD) of the Ministry of Fisheries & Aquatic Resources and all activities of the IFD came to a grinding halt.

Preliminary studies on cage culture of Sea bass in the Negombo lagoon by the private sector under the Coastal Resources Management Project have proved successful. Results conducted with 12 fisher families have shown that, Sea Bass fingerlings stocked in cages reached a size of between 300 to 500 grms in 4 months. The company aims to expand its activities by increasing the number of cages and obtain a production of 3500Mts per year (Annex 3).

NAQDA has recommenced cage culture of mono-sex tilapia with community participation in inland reservoirs. However, it is too early to address this activity as commercial scale cage culture has yet to commence.

Aquaculture Resource Development & Quality Improvement Project (ARDQIP)

As mentioned earlier, this project commenced activities in 2003 under a loan agreement with the ADB. The main technical components of this project are 1) culture base fisheries in seasonal and minor perennial reservoirs, 2) stock enhancement of medium and major perennial reservoirs and 3) fry to fingerling production in mini-nurseries managed by community based organizations (CBOs).

This project has been quite successful in culture based fisheries in seasonal and minor perennial tanks with the foundation research being developed under the ACIAR project. The project has gone several steps further by systematically organizing the village communities to carry out this activity by obtaining loans under the micro-credit schemes being promoted under the project. The village communities are being trained on business plan development and the technicalities of sustainable management of culture based fisheries, especially in minor perennial tanks. The only draw back in culture based fisheries in seasonal tanks is that with the onset of the drought period, there is apparently a glut in production and due to the absence of proper marketing strategies, the price paid to producers tend to fluctuate as a result of factors such as deterioration of quality issues. However, this problem is currently being addressed under the project.

Under the ARDQIP, another activity, which has gained success, is rearing of fry to fingerlings in mini-nurseries managed by CBOs. A number of mini-nurseries have been constructed and managed by CBOs, where the fry produced at the NAQDA Aquaculture Development Centres (AQDCs) are reared to fingerlings for distribution among the fisher community at a price for stocking the perennial and seasonal tanks.

Following are the mini-nurseries constructed under the ARDQIP and managed by CBO’s:

- Mini-nursery – Padaviya
- Mini-nursery – Mahadiulwewa
- Mini-nursery – Kesellanda
- Mini-nursery – Dozer wewa
- Mini-nuresry – Hakwatuna Oya
- Mini-nursery – Kathnoruwa
- Mini-nursery – Ardiyangama wewa
- Mini-nursery – Ridiyagama
- Mini-nursery – Nawamadagama
- Mini-nursery – Elle wewa

In addition to the above, there are private pond operators who purchase fry from the above-mentioned AQDC's, for rearing same to fingerlings for sale and distribution among Fisheries Societies and Farmer Organizations (12).

### *Current Government Policy in Relation to Aquaculture*

The current Government Vision in relation to the Fisheries Sectoris:

'*Sri Lanka to become a leader in the South Asian Region in sustainable utilization of fisheries & aquatic resources, directing the utilization of such resources for the benefit of the current and future generations*'

The major Government policy objectives deriving out of this Vision Statement are as follows;

- To improve the nutritional status and food security of the people by increasing the national fish production
- To minimize post harvest losses and improve quality and safety of fish products to acceptable standards
- To increase employment opportunities in fisheries and related industries and improve the socio-economic status of the fisher community
- To increase foreign exchange earnings from fish products
- To conserve the aquatic environment

The general policy of the Government in relation to inland fisheries and aquaculture development between 1975 and 1990 and from 1995 to present, remains unchanged from the inception of its commencement in mid 70's. Between 1975 and 1990, the general policy was to contribute to the national fish production from inland fisheries and aquaculture. However, the fingerlings stocked in the inland water bodies for enhancing stocks, was carried out as a service to the industry.

A major policy change was made in 1990 to cease Government patronage to inland fisheries and aquaculture by the Government in power at the time. Due to this policy decision the inland fish production dropped from 39,000Mts in 1990 to 12,000Mts by 1995. In 1995, with the change in Government, the policy decision was reversed and Government patronage was re-introduced. The National Aquaculture Development Authority was established by an Act of Parliament in 1998, to continue with the programs carried out prior to 1990. Therefore the basic policies towards inland fisheries and aquaculture development remain unchanged. However, the Authority at present carries out stock enhancement programs and culture based fisheries with community participation and the fry and fingerlings utilized for stocking purposes are now sold at a price to stake holders.

The other major change in policy of the Authority in keeping with the Government policy is to service the Ornamental and Aquatic plants export industry and management and regulation of the shrimp farming industry in Sri Lanka. The Vision, Mission and the Policy Objectives in keeping with Government Policy are as follows;

Vision: TO BE THE APEX ORGANIZATION RESPONSIBLE FOR SUSTAINABLE DEVELOPMENT & MANAGEMENT OF AQUACULTURE AND INLAND FISHERIES TO ENSURE FOOD SECURITY & IMPROVE THE QUALITY OF LIFE OF THE PEOPLE

Mission:

- To contribute to the improvement of the socio-economic status of rural societies by alleviating poverty
- To facilitate the availability and acceptability of freshwater and brackish water aquatic food products to the consumer
- To manage aquatic resources and ensure sustainability
- To create a conducive environment for the development of small, medium & large scale aquatic enterprises

Policy objectives/ Madate

- To develop aquaculture, aquaculture operations and culture based fisheries in perennial reservoirs and seasonal reservoirs, with a view to increase fish production and fish consumption in the country
- To promote the creation of employment opportunities through the development of freshwater aquaculture, brackish water aquaculture, coastal aquaculture and mari-culture
- To promote the farming of high valued fish species including ornamental fish, for export
- To promote the optimum utilization of aquatic resources through environmentally friendly aquaculture programs
- To promote, facilitate and develop small, medium and large scale private sector investment in aquaculture
- To manage, conserve and develop having regard to the need to conserve bio-diversity, aquaculture, aquatic resources used for aquaculture and aquaculture operations and culture based fisheries in perennial reservoirs and seasonal reservoirs
- To assist persons carrying on business as an importer, exporter, seller, distributor and supplier of aquatic resources and engaged in aquaculture and the development of aquatic resources as an importer, exporter, supplier, distributor and seller of aquatic resources
- To prepare and implement plans and programs for the management, conservation and development of aquaculture and aquaculture operations and culture based fisheries in perennial reservoirs and seasonal reservoirs

### *Major Constraints to Inland Fisheries & Aquaculture Development*

The major constraints to inland fisheries and aquaculture are as follows;

Inland Fisheries

- Seed Production Capacity – The fingerlings required for stock enhancement and culture based fisheries is mainly produced at the AQDCs and mini-nurseries managed by CBOs. At present there are 16 such mini-nurseries in the dry and semi-dry zones of the country, where rearing of fry to fingerlings is carried out for sale to Fisheries Societies. However, the production is still inadequate, especially for stock enhancement programs.
- Demand & Marketing – The demand for fingerlings is mostly for culture-based fisheries in seasonal and minor perennial tanks. To sustain the activities of the mini-nurseries and develop same as a livelihood activity, there is a need to continue production of fingerlings when the demand for seasonal and minor perennial tanks is met. To achieve this objective, the fingerlings so produced have to be marketed for stock enhancement of perennial reservoirs, where a demand has still not developed to the same extent as that for seasonal and minor perennial tanks.
- Presence of Vegetation – Some minor perennial tanks are covered with aquatic weeds. At present there is no program by the concerned institutions to eradicate such weeds and for making such tanks suitable for culture based fisheries.
- Over Production – Improper marketing strategies for fresh water fish and lack of value addition could lead to low farm gate prices with lesser returns to the producers.

Aquaculture

- Profitability – Low profits due mainly to lower farm gate prices leads to non-viability of commercial aquaculture operations for freshwater fish.
- High cost of imported fish feeds – Lack of a large-scale freshwater fish aquaculture industry to attract local investors to engage in local fish feed manufacture. Hence the need to import. The same is true for shrimp aquaculture.
-
- Availability of land for freshwater fish aquaculture – There is a lack of suitable large extents of land for large-scale commercial freshwater fish aquaculture. Lands of the Mahaweli Authority with gravity flow water, are already allocated for agriculture activities.
- Agriculture Vs Aquaculture – No concerted efforts made to compare the financial benefits of production per unit area for aquaculture as against agriculture.

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A number of photos were provided with the original manuscript which have been deleted)

Crab Fattening Ponds

Scylla serrata used for crab fattening

Crab fattening cages

## Pakistan

Pakistan is a developing country which is surrounded by Afghanistan, China, Iran and India, on the south is Arabian Sea. It comprises of four provinces namely, the Punjab, the Sind, the NWFP and Baluchistan. Pakistan has following five different types of climates:-

1. Tropical Semi Arid.
2. Tropical Arid.
3. Cold Semi Arid.
4. Snow Forest Climate.
5. Extreme cold.

The country has four well-marked seasons namely (i) Cold Season (December to March) (ii) Hot Season (April to June) (iii) Monsoon Season (July to September) (iv) Post Monsoon Season (October and November). (S.O.P, 1997)

The dominant part of Pakistan's economy is Agriculture including Fisheries. The fish consumption in Pakistan is very low i.e., 2.2 Kg/capita/annum as compared to the world average i.e., 11 Kg/capita/annum (FAO, 2003). The marine fish species are 350 in number (Ayub, 2006). There are about 184 species, of freshwater fishes belonging to warm water, semi-cold and cold water bodies lying in all provinces of the country (Mirza 2003). Among the said fish fauna, *Labeo rohita, Cirrhinus mrigala* and *Catla catla* are being cultured successfully alongwith Chinese carps including *Ctenopharyngodon idella* and *Hypophthalmichthys molitrix.* In suitable areas of the Province of NWFP and in Northern Area of the Province of Punjab, Rainbow and Brown Trouts are also being cultured successfully. Mahaseer (*Tor putitora)* is another important fish found in semi-cold sub-mountainous areas of the country. An anadromous fish, *Tenualosa Ilisha* is also found in river Indus.

The fish species being used for seed production in the country are given in Table 1:-

| LOCAL NAME | SCIENTIFIC NAME |
|---|---|
| Rohu. | *Labeo rohita.* |
| Mori. | *Cirrhina mirgala.* |
| Thaila | *Catla catla.* |
| Mahaser. | *Tor macrolepis.* |
| Silver Carp. | *Hypophthalmichthys.* |
| Grass Carp. | *Ctenopharyngodon idella.* |
| Common Carp. | *Cyprinus carpio.* |
| Bighead Carp. | *Aristichthys nobilis.* |
| Brown Trout. | *Salmo trutta/fario.* |
| Rainbow Trout. | *Onchoryncus mykiss* |

Prior to 1973, the function of the fisheries was merely limited to conservation and management of natural resources, through enforcement of fisheries enactment. There were traditional conservational methods of fisheries and hardly any development programme for the management and utilization of public and private resources for fish culture. There was not a single carp hatchery or nursery unit throughout the country. The fish seed was collected from natural spawning grounds and stocked in rearing ponds.

Table 2. The fish seed production capacity with regard to four provinces of the country is as under:-

| PROVINCE | | PRODUCTION CAPACITY.(In Million) |
|---|---|---|
| Punjab. | Govt. Hatcheries. | 52.000 |
| | Private Hatcheries. | 22.500 |
| Sindh | Govt. Hatcheries. | 18.500 |
| | Private Hatcheries. | - |
| NWFP | Govt. Hatcheries. | 11.750 |
| | Private Hatcheries. | - |
| Balochistan | Govt. Hatcheries. | 0.080 |
| | Private Hatcheries. | - |

From 1974 onward, the induced breeding experiments proved successful and new vistas for promotion of aquaculture practices in the country were opened. In 1974-76 a fish seed hatchery was established at Chhenawan, District Gujranwala (Punjab) having capacity of 15 lacs fish seed production under controlled conditions. Similarly fish hatcheries regarding warm and cold water fishes were established in different provinces of the country for successful propagation thereof.

The province-wise list of Fish Hatcheries in Government sector with regard to Carp, Trout and Mahseer fishes is attached as Annexure-A.

During 1975-78 fish seed nursery units were established at district level in the province of Punjab which were planned to provide fish seed rearing facilities to each district as well as provision of extension services to farmers in the private sector. It was the time when private sector engaged in fish farming and aquaculture practices in the country. In the beginning, from 1977-85 **Chinese fish seed production technology** was introduced. From 1985 onward **glass jar hatchery** technique was introduced due to constraints/ limitation in the Chinese technology as the survival rate of fish at fry stage was quite low. This technique brought a revolution in the availability of fish seed to meet the requirements of public and private sectors.

Upto 1997 the induced spawning fully depended upon pituitary glands (PG) from donors & HCG (human chorionic gonadotrophin) which were administered to the brooders. From 1991-92 “Ovaprim” a synthetic hormonal analog was introduced as a replacement of PG + HCG which brought a real revolution in the field of fish seed production.

### *Water resources.*

There are two major water resources in the country i.e. marine resources and inland or freshwater resources. The main natural freshwater resource of Pakistan is River Indus and its tributaries. After origination from Tibet the river Indus flows behind Himalayan Mountains and then after crossing Northern Areas and Kashmir it turns towards south west. In Northwest Frontier Province it receives such as the Kabul, the Kuram and the Gomal rivers. In Punjab, it receives the Haro, the Soan, the Jhelum, the Chenab, the Ravi and Sutlej rivers. In the province of Sind near Karachi, the river Indus falls into the Arabian Sea. In Balochistan many small rivers and streams such as Lora-Pishin, the Mashkel, the Hub, the Purali, the Hingol and Dasht are included in this respect. (Mirza, 1994)

Table 3. Collectively, the province-wise inland water resources in the country are tabulated with area as below: (Javed-1990, Ahmad-1993)

| WATER RESOURCES | Area (ha) |
|---|---|
| **PUNJAB.** | |
| River and Major Tributaries. | |
| I. Maximum During summer Season | 2940000 |
| II. Minimum during winter season. | 713000 |
| Major Perennial Canals | 22600 |
| Reservoirs attached to Barrages. | 40840 |
| Dams. | 24960 |
| Natural Lakes. | 6700 |
| Water Logged Areas. | 9200 |
| Saline/waste Lands. | 20800 |
| Abandoned Irrigation Canals. | 1440 |
| **SIND.** | |
| Indus and Hub River. | 160000 |
| Indus Delta. | 300000 |
| Lakes. | 101000 |
| Ponds, Dhands and Dhoras. | 98000 |
| Water Logged Areas. | 3000000 |
| Depressions along Road and river flood areas. | 1000000 |
| Canals and Drains. | 32000 |
| **N.W.F.P** | |
| Tarbela Lake. | 26000 |
| Khanpur and other Dams. | 800 |
| Natural Lakes and Artificial Lakes. | 2080 |
| Water Logged Areas. | 1600 |
| **BALUCHISTAN.(Makran Coastal basins)** | |
| Lora-Pishin. | 12250700 |
| Mashkel, Hub. | |
| Purali, Hingol, | |
| Dasht and other streams. | |

The marine resources of Pakistan are derived from the Arabian Sea which has a coastline of 971 Kilometers. The categorization of marine resources along with the area is as below:- (Muhammad, 1988)

| CATEGORY | AREA. |
|---|---|
| Coastal and Shelf region. | 55000 Sq. Km |
| EEZ of Pakistan. | 22000 Sq. Km |
| Makran continental shelf. | 13.33 Km wide. |
| Karachi continental shelf. | 121 Km wide. |

## *Fish consumption patterns*

About 26% of the total fish caught from marine sources is consumed locally and the rest is used as fish meal. Whereas little quantity is exported. Karachi, Hyderabad and coastal areas in Baluchistan are the main points for consumption of marine fish. However, small quantities of marine fish are consumed in the upper parts of the country where Lahore and Rawalpindi have some marketing for marine fish. The fish from inland waters is almost totally consumed throughout up- country.

As a whole the fish consumption in Pakistan is 2 Kg/Capita/annum. The low level of fish consumption is mostly due to the fact that majority of the population prefer red meat and dairy products as protein food. As such, there exists a wide fluctuation in the demand of fish and its price in winter and summer months. However, a table showing fish consumption trend in the past and present is given as below:

| Period | Caput/annum |
|---|---|
| 1970's | 1.5 |
| 1980's | 1.8 |
| 1990's | 2.2 |
| 2000's | 2.2 |

However, as a result of recent consumer education activities to make people aware of the superiority of fish meat over poultry and red meat, the demand for fish is increasing rapidly. Moreover, due to increasing prices of mutton and other meats and changing taste patterns in favour of fish, the demand for fish will further grow rapidly in the next 15-20 years.

### *Fisheries and aquaculture in relation to GDP*

Agriculture has a major contribution in Pakistan economy which is about 26% of gross domestic product (GDP). It also provides 58% of export earning.

The share of Fisheries in this regard is as below:

| CONTRIBUTION OF FISHERIES | |
|---|---|
| ❖ Share in GDP | 1% |
| ❖ Share in Agriculture | 3.5% |
| Fish Production(m.tons) | |
| i- Marine. | 400,700 |
| ii-Inland | 163,400 (Punjab share 30%) |
| ❖ Employment Opportunities. | 365000(Punjab 135,000) |
| ❖ Fisheries Products exported (Inland Negligible/Iregulated) | 84,000 M.tons. |
| ❖ Foreign exchange contribution | US$ 156.254 million. |
| • Source: Economic Survey of Pakistan, 2002-03 | |
| • Hand Book of Fisheries Statistic, Vol:18 | |
| • M.F.D. Statistic. | |

The table showing the trends in Real GDP growth rates for the last 10 years is as below:

| Year | % GDP |
|---|---|
| 1992-93 | 5.6 |
| 1993-94 | 10.9 |
| 1994-95 | - 7.3 |
| 1995-96 | - 2.8 |
| 1996-97 | 4.8 |
| 1997-98 | 5.9 |
| 1998-99 | 0.6 |
| 1999-2000 | 9.7 |
| 2000-01 | - 3.7 |
| 2001-02 | - 12.00 |
| 2002-03 | 16.6 |
| 2003-04 | 2.0 |
| 2004-05 | 2.2 |
| 2005-06 | 1.9 |

Economic Survey of Pakistan (2005-06)

The growth rate of GDP regarding aquaculture/fisheries shows a positive trend except a negative trend in 1994-95, 1995-96, 2000-01 and 2001-02. The negative trends were due to over fishing and drought in natural water bodies.

### *Aquaculture production trends*

The aquaculture practices almost two decades back were restricted to merely extensive farming based on inputs of fish seed from nature comprising local species of fish. From the year 1974, in the Province of Punjab, the success in fish seed production experiments and introduction of semi-intensive production system along with exotic fish species opened new vistas for promotion of aquaculture. As such, the annual growth rate in fish farming area in the early period of last two decades became 5 – 7%. Later on, due to introduction of modern aquaculture and latest technologies in this field through Second Pakistan Aquaculture Project (ADB Assisted) from 1990 to 1995 and onward the fish farming growth rate was much improved and reached upto 16 – 17%.

The modern aquaculture technologies so developed were also disseminated to other provinces of the country by the Province of the Punjab for maximizing aquaculture production. In this regard a table from an FAO publication entitled "Pakistan-Investment Potential on Inland Fisheries and Freshwater Aquaculture Project" (UTF/PAK/092-Identification Mission Report-2003) is reproduced below:

Although the aquaculture production figures are comparatively low in case of the provinces of Sindh, NWFP and Baluchistan yet the production in the province of the Punjab is not only higher but also at par with the Indian State of Eastern Punjab.

As per the growing trends in aquaculture production and conducive governmental policies it can be predicted that aquaculture production will be much enhanced with special reference to the province of Punjab.

PRODUCTION OF CARP PRODUCING PONDS/FARMS (Tons/Ha./Year)

| NAME OF PROVINCE | PRODUCTION |
|---|---|
| PUNJAB | 2.5 – 3.7 |
| SINDH | 1.5 – 2.5 |
| NWFP | 1.2 – 2.0 |
| BALUCHISTAN | - |

(Pedini & Ayub, 2003)

### *Major development programmes*

During the last two decades, two major development programmes in relation to aquaculture were undertaken in the country at national level with the financial assistance of Asian Development Bank (ADB). These programmes were implemented with the gestation period and total cost as below:

| Name of the Project | Gestation Period | Total Cost (Rs. Million) | Location |
|---|---|---|---|
| 1st Pakistan Aquaculture Development Project | 60 Months (from July, 1981 to June, 1986 | 44.986 (Punjab) | National Level |
| 2nd Pakistan Aquaculture Development Project. | 78 Months (from July, 1989 to December, 1996 | 235.269 (Punjab) | -do- |

During the recent past the Punjab province of Pakistan has taken viable development initiatives for protection of endangered/threatened fish species of economic value i.e., Mahseer (Tor macrolepis), Kalbans (Labeo calbasu), Singhari (Sperata singhala) and Saul (Channa marulius) to conserve the biodiversity in the natural fisheries resources. Out of these Labeo calbasu and Mahaseer fish species have been bred successfully and seed production thereof is being stocked in the natural water bodies.

Under a development project, the work on artificial breeding of Singhari and Saul is in progress. During 2004, Mahaseer fish has been successfully bred in Pakistan artificially first time in South East Asia which is a remarkable success. Various efforts have been made for the artificial breeding of Mahseer fish in the neighbouring countries but they have not succeeded, so far. In this way Pakistan has taken a lead over other countries in the South East Asian region.

### *Critical evaluation of development programmes*

Both of the Development projects mentioned at 4.c played a successful role in up-gradation of aquaculture practices in the country. These projects not only improved the capabilities of the Fisheries Department in the country but also extended the facilities for boosting up aquaculture production. These projects also strengthened the research and training activities to enhance fish production not only through farming but also through management of open water bodies in all the provinces of the country.

### *Government policies*

Specifically no national fisheries and aquaculture policy has been made in Pakistan in the past. Fisheries issues were covered, to various extents under agriculture policies or livestock policies. Although report of the Agriculture Enquiry Committee in

1970's and National Agriculture Commission Report 1987 gave some attention to the fisheries sector, they did not make a major impact because the sectoral problems were, inadequately addressed. Policies have, however, been made for deep sea fishing in 1988, 1995 and 2001 but these were specifically aimed for the promotion of fishing under licensing arrangements in the Exclusive Economic Zone of Pakistan and only marginally covered aspects of local/small-scale coastal fisheries.

### *Exercises for Policy Formulation.*

During the month of December, 2004 the Government of Pakistan had constituted a task force for fisheries policy formation under the chairmanship of Minister concerned as per the instruction of Prime Minister Secretariat. The task force in its first meeting framed two working group one each on Inland headed by Dr. Muhammad Ayub, Director General Fisheries, Punjab and on Marine Fisheries headed by Commodore Syed Qamer Raza, Director General Marine Fisheries Department Karachi. During the year 2005 the both working groups (Inland & Marine) have submitted their policy drafts. The outcomes from the two working groups were amalgamated into a single "National Fisheries Policy" draft. Later-on on the request of Government of Pakistan FAO provided support to Fisheries sector policy and strategy formulation under a TCP project entitled "TCP/PAK/3005". Accordingly, an FAO TCP Inception Workshop was conducted in June 2005, a report was prepared after consultation with wide range of stakeholders a detailed project implementation plan was prepared. Accordingly the contents of this draft policy were synthesized into a 'policy brief' by the international consultant hired by the project, and taken, with the assistance of NACA-STREAM, through a first round of community consultations across the four provinces. The policy brief was also sent to numerous stakeholders from Provincial/Areas Governments, Harbour authorities, NGOs etc. who provided their comments in written form. Based on what was learned and recorded during this first phase of community consultations and the feedback received from consulted stakeholders, the draft policy was then redrafted by FAO. Task force members and other project stakeholders from the Government of Pakistan, NACA and an international fisheries consultancy company (Poseidon Ltd.), made observations on its contents, which were then further revised by FAO until a consensus was reached. A round of Provincial/Areas stakeholder consultations followed, in the participants gave their inputs for prioritization of the various recommendations made in the draft policy document, and on its implementation. Following these Provincial/Areas stakeholder consultations in two districts of each of the four provinces, the policy document was further modified and re-named "National Policy and Strategy for Fisheries and Aquaculture Development in Pakistan".

Moving upwards from communities to Provincial/Areas governments, the policy document was then presented at two Provincial/Areas Workshops to representatives from a wide range of government and non-government institutions and organizations from the four provinces concerned as well as areas of the country. Workshop participants used the draft "National Policy and Strategy for Fisheries and Aquaculture Development in Pakistan" as the basis for practical discussion about implementation issues and priorities, and reflected on specificities (e.g. partnership necessary, timelines, funding and targets) of the activities to achieve the strategy objectives.

Outputs from the Provincial/Areas workshops were then incorporated into the "National Policy and Strategy for Fisheries and Aquaculture Development in Pakistan" draft, which was further refined into a final draft.

The contents of this final draft document, and in particular sections related to the implementation of policy, were thoroughly discussed during a national workshop gathering federal-level government officials from MINFAL and other in-line ministries as well as provincial/areas departments, and Chief Province Secretaries. Based on the outputs of the workshop, final amendments were brought to the draft policy document, which was then presented to the Secretary of MINFAL.

The legal implications of the “National Policy and Strategy for Fisheries and Aquaculture Development in Pakistan” were evaluated by a Fisheries legislation expert and are reported in appended Part 2. The present policy document was then submitted, along with suggested legislative amendments, to the Cabinet for its approval.

Institutional arrangements to support the implementation of the policy, in harmony with the Government’s desire to emphasize agri-business approaches to the development of the fisheries and aquaculture sectors and supported by a number of concept notes for umbrella projects which have been formulated to strengthen the implementation of the policy, are outlined in the National Policy and Strategy for Fisheries and Aquaculture Development in Pakistan.

This policy document was considered and cleared at Federal Government level during May, 2006 and is likely to be presented before Prime Minister of Pakistan for its final approval. The said policy covers all the aspects of fisheries and aquaculture both in marine and inland sectors with the following fundamental common elements:

- Strengthening of cross-sectoral collaborations.
- Institutional improvements and developments.
- Enhancement of research and development applied to fisheries and aquaculture.
- Development of human resources and skills.

These above common elements are the pre-requisites to the realization of three technical strategy axes as below:

- Sustainable development of inland and coastal aquaculture production.
- Sustainable increase in inland and marine capture fisheries production.
- Resolving post-harvest issues.

The above common elements strive to create an enabling environment. The strategy axes relate to technical directions covering the development of inland and coastal aquaculture, marine and inland capture fisheries, and resolving of post-harvest issues. Strategy axis at Sr. No.3 deals with the handling, storage, value-adding / processing, transport and marketing/commercialization of captured and cultured species. (MINFAL, 2006)

### *Planning During the Past and Present*

In Pakistan, the planning process has evolved through four distinct stages and the planning machinery from a humble and an insignificant beginning has come to occupy a crucial position in the development strategy of the country.

The initial Five year plans were not very well conceived and worked out, as pointed out by Mahbub-ul-Haq “The plan was nothing but a public investment programme and included a loose aggregate of projects which had been chosen on adhoc basis without reference to available resources and needs of the economy. For certain sectors (e.g. Agriculture/Fisheries) where no schemes were readily available, lump sum provisions were made. However, no overall targets were set for the economy and attempts to relate projects to targets were lacking".

The importance of Fisheries as an excellent source of animal protein and its economic value is asserted in all the plans starting from First Five year plan (1955-60). Inspite of this recognition very little was done for its development in terms of financial allocations and plan preparation.

The fifth five year plan (1977-83) however, really proved to be a milestone for the development of inland fisheries on scientific lines. The plan provided a much needed boost to this sector. The total allocation for the Punjab during this plan was Rs.51.151 million (Ayub, 1985).

The subsequent plans upto 10th five year plan (2006-2011) however, gave important guidelines regarding fisheries policy which were also implemented with true spirit producing a positive impact on the fisheries sector.

### *Major constraints to aquaculture development*

The major constraint in Aquaculture Development in the past was non-availability of quality fish seed of culturable fish species in the requisite number as per demand as the same was completely dependant on its procurement from nature. However, with the success in Induced Breeding of culturable fish and perfection in fry rearing techniques, this constraint was successfully overcome in the last two decades.

The current constraints which would likely to persist in future are drought and aquatic pollution in the development of fisheries and aquaculture. Moreover, in view of WTO bindings, the free import of fish may increase such imports at cheap prices from the neigbouring countries with low power rates which would affect the aquaculture development in country negatively.

Furthermore, the country is presently facing certain other important challenges and inadequacies detailed as under:

- Lack of post-harvest facilities causing quality deterioration.
- Lack of modern transportation facilities from landing centers to markets.
- Lack of well established fish markets in the country.
- Inadequacy of fish processing industry.
- Lack of quality control facilities.
- Discontinuation of income tax exemption on income through fish farming.
- Insufficient financial incentives, grants and aids, etc., for mobilization of resources in the private sector.
- High rates for the import of chemicals, drugs, feed and allied aquaculture equipment.
- Addition of untreated industrial effluents and Urban/hospital wastes into natural water bodies.

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