

Add fisheries and aquaculture management to our solutions for climate change and food security

M. K. Das
and
A. P. Sharma



Fisheries Resource and Environmental Management Division

Central Inland Fisheries Research Institute

(Indian Council of Agricultural Research)

Barrackpore, Kolkata - 700 120

Add fisheries and aquaculture management
to our solutions for climate change
and food security

Dr. Manas Kr. Das

and

Dr. A. P. Sharma



Bulletin No. 167

December 2010

Fisheries Resource and Environmental Management Division

Central Inland Fisheries Research Institute

(Indian Council of Agricultural Research)

Barrackpore, Kolkata - 700 120, West Bengal

ADD FISHERIES AND AQUACULTURE
MANAGEMENT TO OUR SOLUTIONS FOR
CLIMATE CHANGE AND FOOD SECURITY

Authors

Dr. Manas Kr. Das

and

Dr. A. P. Sharma

© 2010, Central Inland Fisheries Research Institute, Barrackpore

ISSN : 0970-616X

Published by

Dr. A. P. Sharma, *Director*

Central Inland Fisheries Research Institute

Barrackpore, Kolkata - 700 120, West Bengal

Printed at

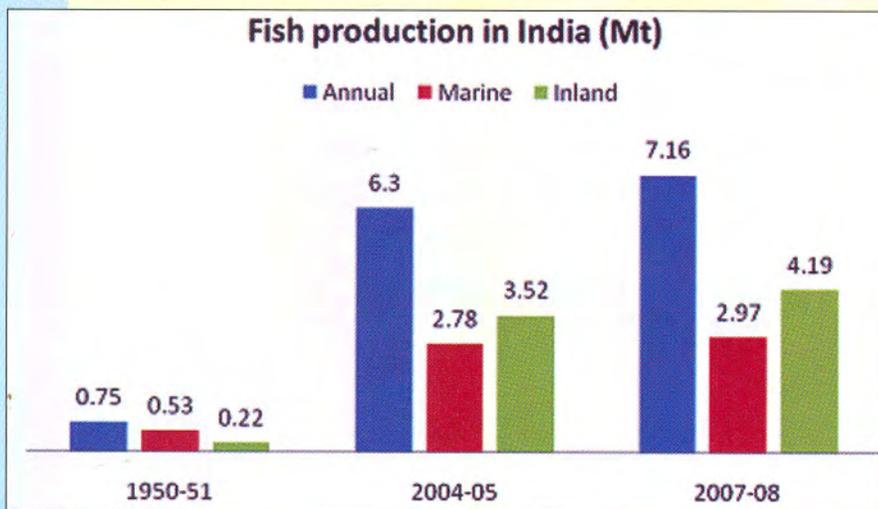
Eastern Printing Processor

Add fisheries and aquaculture management to our solutions for climate change and food security

The year 2010 has been declared as the world's warmest year by WMO and in India the decade ending with 2010 has been declared the warmest decade by India meteorologists. Thus the major environmental challenge of 21st century is global warming and the associated climatic change. Climate change is projected to impact broadly across ecosystems, societies and economies, increasing pressure on all livelihoods and food supplies, including those in the fisheries and aquaculture sector. Since fisheries and aquaculture depend heavily on climate it is imperative to think of the vulnerability and adaptation strategies in dealing with the impending change.

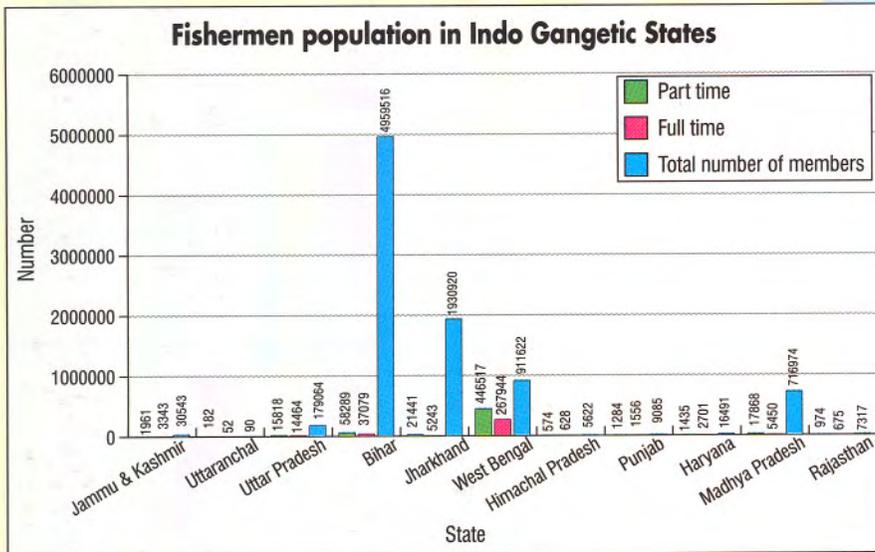
Significance of fisheries and aquaculture in India

Fisheries and aquaculture sector in India provides nutritious food, has high potential for rural development, domestic nutritional security, employment generation, gender mainstreaming as well as export earnings. India is a major maritime state and an important aquaculture country in the world and occupies third position in fisheries and second in aquaculture production. The Fishery sector has shown a steady growth in India and hence it is called the sunrise sector. Indian share in global fish production is 4.36% with 9.92% in inland and 2.28% in marine. Its contribution to the National GDP is 1.07%, to National Agriculture and allied activities 5.84%. The Export potential is 18% of agricultural exports (50 products)

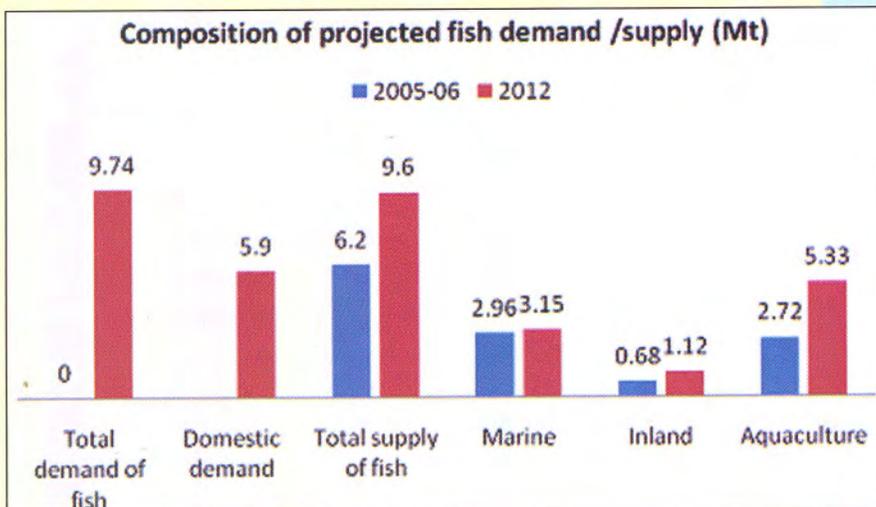


(Source Hand book of Fish Statistics, MOA, GOI 2008)

It provides direct and indirect engagement in fisheries sector to 14 million people.

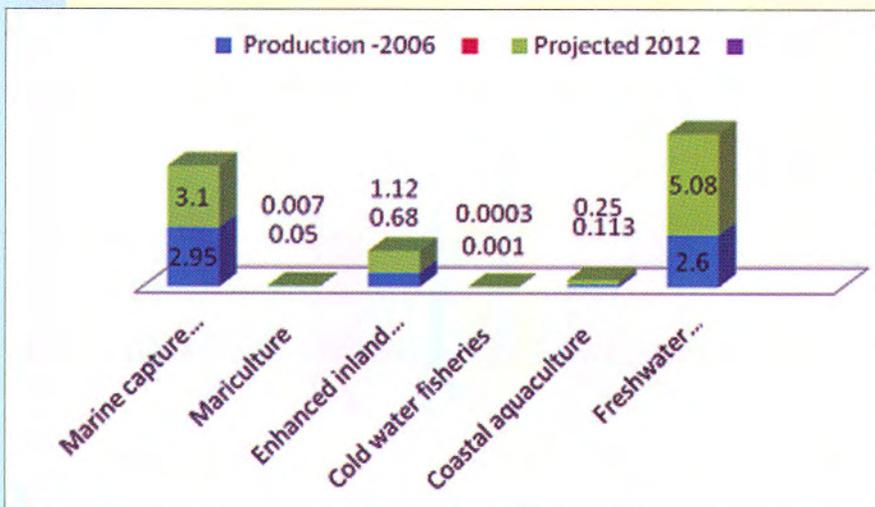


The fish supply/ demand position in India at present indicates a minimum shortfall in supply compared to the demand



Fisheries Div.ICAR,2006NCAP,2006 ,Kumar,2005

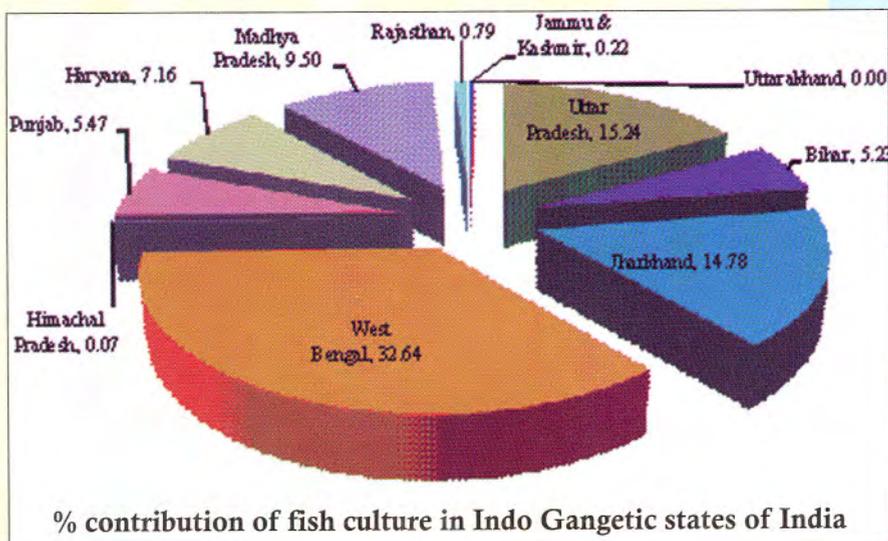
To meet the projected demand emphasis is on the expansion of Inland Fisheries in general with special importance on Fresh water Aquaculture.



Source (Fisheries Div. ICAR, 2006)

Freshwater aquaculture has grown from 46% in mid 1980s to 80% in recent times. It is one of the fastest growing enterprises in agriculture. Success of aquaculture sector has important implications both in terms of food security, as source of income, for a growing number of people. Consequently any potential direct or indirect effects of climate change need to be taken seriously.

The fisheries sector differs from mainstream agriculture and has distinct interactions and needs with respect to climate change. Aquaculture complements and increasingly adds to supply and, though more similar to agriculture in its interactions, has important links with capture fisheries.



What are the Climate Change predictions for India

Some of the recent assessments on global warming and climate change of relevance to inland fisheries conclude that :

Surface air temperature : At the national level has increased by 0.4°C over the past century.

Rainfall : While the observed monsoon rainfall at the all-India level does not show any significant trend, regional monsoon variations have been recorded.

Extreme Weather Events : Trends observed in multi-decadal periods of more frequent droughts, followed by less severe droughts. There has been an overall increasing trend in severe storm incidence along the coast of West Bengal and Gujarat and a rising trend in the frequency of heavy rain events.

Rise in Sea Level : A sea level rise between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC.

Impacts on Himalayan Glaciers : The Himalayas possess one of the largest resources of snow and ice and its glaciers form a source of water for the perennial rivers such as the Indus, the Ganga, and the Brahmaputra. The available monitoring data on Himalayan glaciers indicates that while recession of some glaciers has occurred in some Himalayan regions in recent years, the trend is not consistent across the entire mountain chain.



Ways by which Inland fisheries will be affected by climate change

While many of the climatic changes given impede development of fisheries and aquaculture, but at the same time they provide new opportunities for development.

Change	Effects
Enhanced water temperature	Culture system : Reduced (DO), Enhanced primary productivity Increased growth and food conversion Increased disease incidence Enhanced breeding period in hatcheries
	Operational Changes in level of production,(ponds, hatcheries) Operating cost Increase in capital costs (aeration, deeper ponds) Changes in level of production, (ponds, hatcheries)
	Rivers Geographic shift of fishes, Species richness Breeding failure Habitat loss/gain
	Wetlands Increased stratification and reduced mixing of water in lakes and reservoirs, reducing primary productivity and food supply to fish species.
Floods	Culture system Salinity changes Escape of fish stock Structural damage Introduction of disease predators
	Operational Loss of fish stock Damage to facilities Higher capital costs for flood resistance Higher insurance costs
	Rivers Changes in fish migrations and requirement patterns and in recruitment success.
Intense storm surges (coastal region)	Culture Inundation and flooding Salinity changes Escape of fish/prawn stock Introduction of disease and predators
	Operational Loss of prawn/ fish stock Damage to facilities Higher insurance costs

Change	Effects
Drought	Culture system Salinity change Reduced water quality Limited water volume for aquaculture Increased competition with other water users Operational Loss of fish stock Limited production
Sea level rise	Loss of land, Changes to estuary system Loss of coastal ecosystems such as mangrove forests
Water stress (as a gradual reduction in water availability)	Culture Decrease in water quality Increased diseases Reduced pond level Altered and reduced freshwater supply Operational Cost of maintaining pond level artificially Conflict with other water users Loss of fish stock Reduced production capacity Change of culture species
Human adaptation to changes in climate	Aquatic ecosystems including Fish and Fisheries Exacerbation of negative impact Example 1 : Increased demand of water for irrigation <i>Supply side options</i> Increasing supply, Expensive, Environmental impact <i>Demand side options</i> Reducing demand Increase irrigation efficiency Higher prices Changes in cropping pattern Example 2 : Flood Control <i>Supply side options</i> Increasing flood protection with levis, and reservoirs Expensive Environmental impact Catchment source <i>Demand side options</i> Improvement in flood warning system and information

How would Inland fisheries cope with climate change

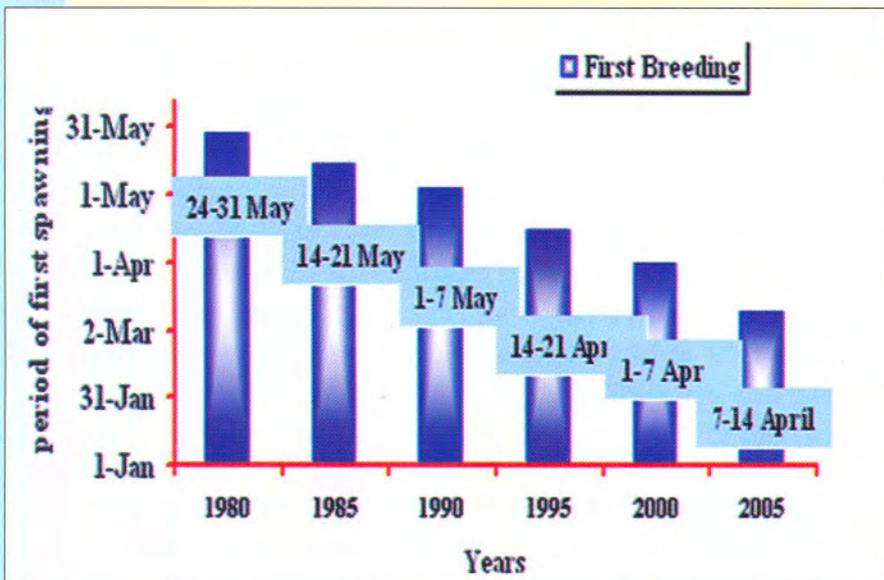
Enhanced temperature

Growth of Fish —Temperature changes will have an impact on the suitability of species for a given location. In temperate areas increasing temperatures could bring the advantages of faster growth rates and longer growing seasons. Similarly for the Indian Major Carps the growth rate increases upto 33°C but from 34°C and above feeding is reduced and growth diminishes.

Investigations were conducted to assess the impact on the growth of Indian Major Carp, *Labeo rohita* fingerlings reared under unit rise in temperature in seven thermostatic aquarium for five weeks at water temperature of 29°C, 30°C, 31°C, 32°C, 33°C, 34°C and 35°C. Fish reared at 34°C water temperature exhibited a significantly ($P < 0.05$) faster growth (SGR-2.36 % body weight per day) than those at other temperatures. The change in growth rates were insignificant between 29°C, 30°C, 31°C and 32°C treatment groups but growth rates significantly increased in the temperatures ranging from 32°C to 34°C and there after it decreased. A linear growth model of *Labeo rohita* fingerlings growth has been developed using the data generated. This simple growth model provides a reliable projection of growth (SGR %) with unit rise of temperature within the range of 29° to 34°C. Assuming these growth rates are constant, it would take average 77 days for a fish to double its weight at 30°C to 33°C and 35°C, but at 34 °C it would take only 35-36 days.

Enhanced breeding period of fish —Inland aquaculture is centered around the Indian major carps, *C. catla*, *L. rohita* and *C. mrigala*. These fishes are bred in captivity by the technique of hypophysation and their spawning occurs during the monsoon season (June-July) and extends till September. In recent years the phenomenon of IMC maturing and spawning as early as March is observed.

Elevated temperature range (0.37°C-0.67°C) and alteration in the pattern of monsoon proved a major factor for shifting the breeding period of Indian major carps from June to March in fish hatcheries of West Bengal and Orissa. Investigations conducted indicate an extended breeding period of Indian major carps by 40-60days, with breeding season extending from 110-120 days (Pre1980-85) to 160-165 days (2000-2009) at present in fifty fish seed hatcheries in four districts of West Bengal, India viz. North 24 Parganas, Bankura, Burdwan & Hooghly. This has provided opportunities to the farmers to avail of the extended breeding period in producing valuable fish seed and supplement their income.



Geographical shift of fishes — A perceptible shift was observed in geographic distribution of the warm water fish species, *Glossogobius giuris*, *Puntius ticto*, *Xenentodon cancila* and *Mystus vittatus* towards the colder stretch of the river Ganga up to Haridwar with an enhancement of annual mean minimum water temperature of 1.5°C in the Haridwar stretch during the period 1970-86 to 1987-2009. This stretch has become a congenial habitat for these warm water fishes of the middle stretch of the river. As a result a possibility of enhanced yield and diversity in their fish catch from the stretch has been created.

Adaptation options

These options can primarily be affected in the culture system through

- Making changes in feed formulations and feeding regimes of fishes
- Exploring substitution by alternate species of fish
- Providing monetary input to the changes in operational costs in ponds and hatcheries

Flood

Increased flooding may expand the number and quality of water areas available for cultivating fish. The experience in the unprecedented floods in Bihar during 2008 affecting huge loss of life, property, agriculture and fisheries showed that at the same time the post flood management measures provided opportunities to fisheries and aquaculture in offsetting some of the losses incurred by the people.

Adaptation options

- *Post – flood :*

The floods affected 6051 ha of fish culture areas in various districts of Bihar. The post flood fish seed requirement for stocking this area at the rate of 50 kg /ha of 5-10g size of fish was 300750kg (300t) of fish seed.

Thus continuous supply of fish seed from hatcheries or raising of fish seed in hatcheries became necessary.

Cage culture in in large water logged bodies for raising seed from fry to fingerlings was advocated.

- *Pre- flood :*

Harvesting fish at smaller size

Giving importance to fish species that require short culture period and minimum expense in terms of input

Increasing infrastructure sophistication of hatcheries for assured seed production of 34,000 million carp fry, 8000 and 10000 million scampi and shrimp PL respectively.

Intense storm surges and sea level rise

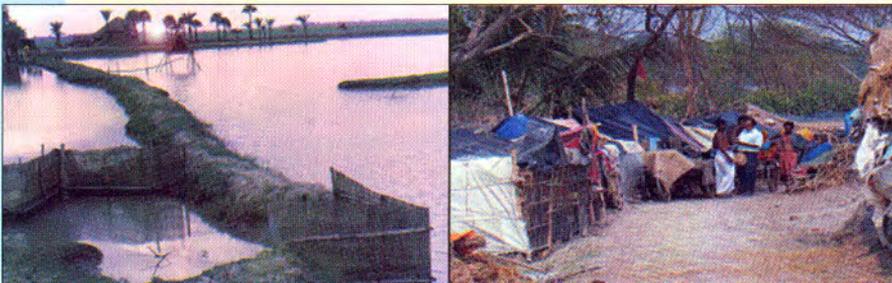
Increased flooding may expand the number and quality of water areas available for cultivating fish. This will have wider applicability as coastal- floodplain zones expand with rising sea level. and storm surges.

During the Cyclone Aila devastation more than 70% people were either made homeless or had their livelihoods disrupted. Damages included loss of income, destruction to fish ponds, bheries and gear, as well as other assets. Fishers were totally dependent on fishing and wild fish seeds collection from natural resources as the only source of income.

Adaptation options

- *Post ingress :*

The ingressed saline water inundated paddy fields which became unfit for agriculture. These areas provided temporary opportunities for converting these areas into ponds for fish culture with saline tolerant fish species *viz. Mugil parsia, M. tade and Lates calcarifer.*



● *Pre-ingress :*

Early detections systems of extreme weather events

Communication of early warning system

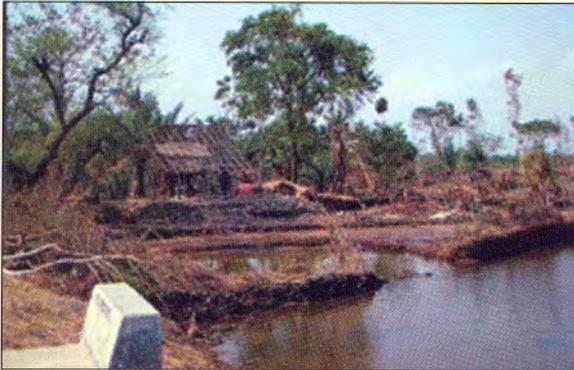
Accept certain degree of loss

Development and implementation of alternative strategies to overcome these periods

Maximizing production and profits during successful harvest

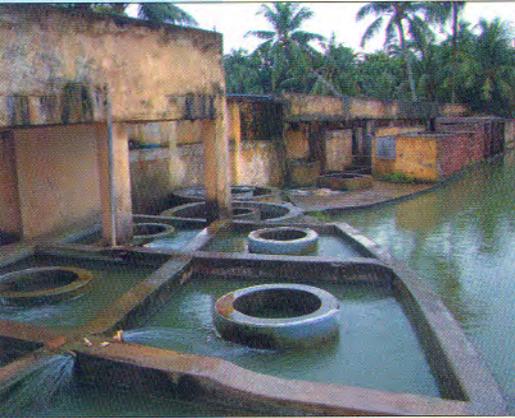
Suitable site selection and risk assessment work through GIS modelling

Increasing infrastructure sophistication of hatcheries for assured seed production of 34,000 million carp fry, 8000 and 10000 million scampi and shrimp PL respectively.



Drought

During the drought prevailing in West Bengal in 2009, the deficit in rainfall was within the range of 25% and 37% during the fish breeding months (April to Sept) in districts of Bankura and N 24



Prgs. respectively compared to previous years . This has created a situation of water scarcity in fish rearing and culture ponds of West Bengal. Breeding commenced in the month of March but the total number of successful days were restricted to 98 during 2009 in comparison to 150-155 days in previous years .The total fish spawn production came down to 40 lakhs/100 kg fish brooders from 130-140 lakhs/100kg in fish seed hatcheries in Bankura

Adaptation options

- *Pre- drought :*

80 % of the hatcheries due to the drought condition diverted from rearing Indian Major Carps to other species like Pangasius (*Pangasius sutchi*), *Puntius javanicus* and *C.garipenus*, which favourably adapt to water stress and high temperature condition.

- *Post- drought :*

Smaller ponds that retain water for 2-4 months can be used for fish production with appropriate species (catfish, tilapia etc.) and management practices.

- Increasing infrastructure sophistication of hatcheries for assured seed production of 34,000 million carp fry, 8000 and 10000 million scampi and shrimp PL respectively.

Water stress

Prediction for water availability as a result of climate change in India indicate water stress in coming years. This would result in decreasing water availability in the major river basins of India. The Gangetic plains and delta are regions of significant aquaculture activity contributing to fish seed production, to income and providing livelihood to thousands of fishers. Thus judicious use of this primary

resource is of topical importance for sustaining fisheries and aquaculture in reservoirs, wetlands and other ponds and tanks. The comparative water needs for unit production are given below :

Specific water demand (m³/t) for different animal food products* and comparison with needs for aquaculture

Product	Water demand
Beef, mutton, goat meat	13 500
Pig meat	4 600
Poultry	4 100
Milk	790
Butter + fat	18 000
Common carp (intensive/ponds)a	21 000
Tilapia (extensive/ponds) a	11 500
Pellet fed ponds b	30 100

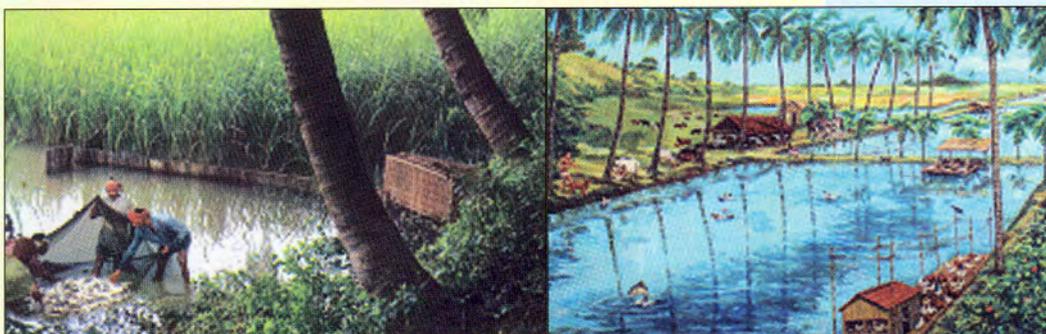
(Source : a- Muir,1995: b- Verdegem, Bosma and Verreth, 2006.

Source : *data from Zimmer and Renault, 2003)

Pond aquaculture when practiced for culturing shrimp and carnivorous fin fish species is water consuming but some other enhancement technologies such as cage culture is totally non-water consuming, except for the need for feeds. Further culture based fishery in pond fed with natural feed, or selected feed ingredients requiring little water to produce,needs encouragement.

Adaptation options

- Multiple use, reuse and integration of aquaculture with other farming systems
- Intensification of aquaculture practices in resources of wastewater and degraded water such as ground saline water



- Smaller ponds (100-200m² of seasonal nature (1-4) months can be used for rearing /culture of appropriate species of fish/prawn
- Increasing infrastructure sophistication of hatcheries for assured seed production of 34,000 million carp fry, 8000 and 10000 million scampi and shrimp PL respectively



Carbon sequestration

16

Aquaculture in India and in other Asian countries is predominantly dependent on fish species feeding low in the food chain and act as carbon sink and aid in carbon sequestration. Though cultured shrimp and carnivorous finfish feeding mainly on fishmeal and fish oil for feeds contribute to carbon emissions.

Aquaculture of Indian and exotic carp uses minimal industrial energy but has a potential significance in the carbon cycle, fixing CO² through phytoplankton. Aquaculture thus has the scope of alternative practices being adopted in response to climate change to reduce the sectors contribution to GHG emission.



Adaptation options

Adoption of simple techniques of providing a suitable and/or enhanced food source(s) for cultured stock through measures to increase phytoplankton and periphyton growth could be a major energy saving measure .

Periphyton-based practices have developed independently and are used to catch fish in open waters in various parts of the world. In India (West Bengal) the practice is known as *Komor* or *Huri*, in Bangladesh it is called *Katha*, in West Africa *Acadja*, and in Cambodia *Samarahand*. In West Bengal the practice is essentially fixing vertically unused bamboo sticks, tree branches to act as substrates for colonization by the plankton, microbes, invertebrates and other organisms that make up periphyton, in the various household tanks so commonly found in the rural areas. The farmers in this part of India and Bangladesh traditionally believe that *shaola* (periphyton) growing on the substrate form food for the fish and serve as protection against poaching of fish. Indian major carps are grown in these ponds for fish culture to sustain the rural population. In Bangladesh the best result has been achieved if the surface area of the substrate is equal to approximately 50-100% of the pond's surface area. The technology seems to hold promise for the farming of any herbivorous fish which is capable of harvesting periphyton from substrates.



GIS mapping for vulnerability assessment

Assessment of coastal areas : To assess the impact of cyclonic events like AILA on coastal areas of South 24 parganas Digital Elevation Model was generated from SRTM (Shuttle Radar Topographical Mission) of 90m spatial resolution data. Contour lines were created with the help of TNT Mips software in meter. The extent of land that may be submerged under scenarios of sea water rise show 3% land will be submerged in case of 1m sea level increase. But it is also observed due to cyclonic sea ingress upto 2m agricultural fields and aquaculture pond are affected. A total of 11% area of South 24 Parganas is highly vulnerable to cyclonic events.

Adaptation options

- Salinity intrusions that render areas unsuitable for agriculture, particularly for traditional rice farming, could provide additional areas for culturing valued shrimps and other estuarine fish species. If these shifts are to be made, major changes in the supply chains have to be adopted and nations should build these needs into their planning and forecasting.
- Sea level rise and saline water intrusion will also impose ecological and habitat changes, including mangroves that act as nursery grounds for many euryhaline species.



Development of a unified strategy

Improvement of water productivity through higher yields, crop diversifications, and integrating livestock fisheries, is an effective way of improving rural income, alleviating poverty and reducing risk by diversifying income sources. Thereby improving community resilience and reducing environmental degradation that exacerbates climate change. A common framework should be created at the country level that can be used towards implementing the integrated watershed management strategy starting from Gram Panchayat (village council) to the river-basin level in a unified manner. Integrated watershed management does not merely imply the amalgamation of different activities to be undertaken within a hydrological unit. It also requires the collection of relevant information, so as to evaluate the cause and effect of all the proposed actions. This framework will need regular maintenance and updating to fully reflect the most accurate ground truth data. Local planning and management strategies have to be evolved and validated through the proposed framework, so as to generate and evaluate various options suitable for local conditions. This would greatly help inland fisheries development in future.

Project addressing climate change and Inland fisheries at CIFRI

- ICAR Network Project Impact, Adaptation and Vulnerability of Indian Agriculture to Climate Change- Impact Assessment of climatic change on inland fisheries'

For further information

1. Das, M.K., Maurey, P., Brahmane, M.P., Mukhopadhyay, M.K. & Saha, P.K. (2007). Impact, Adaptation and Vulnerability of Inland Fisheries to Climate Change. *Journal of Indian Association, for Environmental Management*. 34(2), 68-76
2. Dey, S., Shrivastava, P Maji, S., Das, M. K. Mukhopadhyay, M. K. and Saha, P. K. 2007 Impact of climate change in the breeding of Indian Major carps in West Bengal, *J. Inland Fisheries Society of India* 39(1) :26-34
3. Das M. K. and Saha P.K. 2008. Impacts and adaptation of inland fisheries to climate change in india Bull No. 151. CIFRI, Barrackpore. p 26.
4. Vass K. K., Das M.K., Srivastava P. K. & Dey 5.,2009 Assessing the impact of climate change on inland fisheries in River Ganges and its plains in India, *Aquatic Ecosystem Health & Management*, 12 (2) : 138-151
5. Das M. K. 2009. Impact of recent changes in weather on Inland fisheries in India, *In P.K.Aggarwal (ed) Global Climate change and Indian Agriculture- Case studies from the ICAR Network Project* . Published by Project Director (DIPA), Indian Council of Agricultural Research New Delhi. pp. 101-103.

6. Das M. K. 2010. Climate change Impacts on Inland fisheries - Issues and strategies – *Lead Papers*, National Symposium on Climate Change and Rainfed Agriculture, February, 18-20, 2010, CRIDA, Hyderabad, India, pp 146-159.
7. E. Vivekanandan and Das, M.K. (2010). Impacts and Adaptation of Fisheries to Climate Change In India. *In Handbook of Fisheries and Aquaculture*. Published by Director of Information & Publication of Agriculture, Indian Council of Agricultural Research New Delhi. (In press).

Reach us

Fisheries Resource and Environmental Management Division,
Central Inland Fisheries Research Institute
Barrackpore, Kolkata - 700 120
website : <http://www.cifri.ernet.in>
Telephone : 033-2592 1190/1191/0331, 2545 1065
Fax : 033 2592 0388/2545 1063