Agrometeorological Techniques for Risk Assessment and Management of Extreme Events

Editors

B Bapuji Rao
VUM Rao

All India Coordinated Research Project on Agrometeorology
ICAR-Central Research Institute for Dryland Agriculture
Santoshnagar, Hyderabad - 500 059, India

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Risks Associated with Extreme Weather in Aquaculture and Their Management

M Muralidhar and K K Vijayan

Introduction

The most notable and significant changes associated with global warming are a gradual rise of global mean temperatures. Some of the developing world's largest rivers are drying up because of climate 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. Food fish, whether captured or cultured plays an important role in human nutrition & global food supply, particularly within the diet and food security of the poor. Aquaculture is the only option to meet the increase demand of aquatic food supply in the next 20 to 30 years as globally capture fisheries has already reached a plateau during which climate change impacts are expected to widen and increase. In India, fisheries and aquaculture is one of the important food producing sectors providing livelihood to about 15 million people and maintained a sustained growth of around 10% for the last three decades. Coastal aquaculture in India is synonymous with shrimp aquaculture and freshwater aquaculture is dominated by carps farming. Aquaculture, similar to agriculture in its interactions and the aquatic environment will respond to climate changes in ways that are as equally significant as the responses of the terrestrial and atmospheric environments. However, the precise and localized impacts of climate change impacts on fisheries and aquaculture is less well documented than for other primary production sectors.

Climate change drivers and their implications for aquaculture

The predictions of climate change in the country viz., increasing trends in annual mean temperature, frequency of hot days and multiple-day heat wave, more warming during post monsoon and winter, increase in extreme rains in north-west during summer monsoon in recent decades, consequent droughts, and extreme climatic events (ECEs) are likely to be the most significant drivers that has greater impact on aquaculture. The impacts on aquaculture from climate change will likely be both positive and negative.

2.1 Precipitation

Variability in the amount of precipitation under different scenarios of monsoon could negatively impact aquaculture. Potential increases in seasonal and annual variability and extremes resulted in lower water availability for aquaculture and increased competition with other agricultural, industrial and domestic users. Failure of monsoon leads to the problem of water scarcity and higher salinity is site-specific with wide variations depending on the tidal amplitude, water current and inflow of freshwater. Alteration of precipitation patterns will alter salinity, nutrients and suspended sediment levels of coastal waters with implications of more diseases for coastal aquaculture. Increased precipitation and flooding leads to infrastructure damage, cause stock to escape, affect salinity, and introduce predators or diseases.

2.2 Temperature

A change in temperature of only a few degrees might mean the difference between a successful aquaculture venture and an unsuccessful one. The impact due to higher inland water temperatures in mid to high latitudes are possible benefits for aquaculture due to consequent lengthening of the growing season for cultured fish and shellfish and increased production of aquaculture species. Increased water temperatures leads to other associated physical changes, such as shifts in dissolved oxygen levels, increase in the intensity and frequency of disease outbreaks and more frequent algal blooms. Changes in timing and success of migrations, spawning and peak abundance due to variations in temperature impact the seed availability for aquaculture.

2.3 Oceanographic variables

The first and second assessment reports on ocean systems concluded that global warming will affect the oceans productivity, which indirectly affects the aquaculture. Changes in sea-surface temperature, variations in wind velocity, currents and wave action causes decrease in the production of fish meal and fish oil for aquaculture feeds, waste accumulation and decreased flushing rate/ water exchanges and carrying capacity of water bodies for aquaculture.

2.4 Extreme climatic events (ECEs) and Sea level rise (SLR)

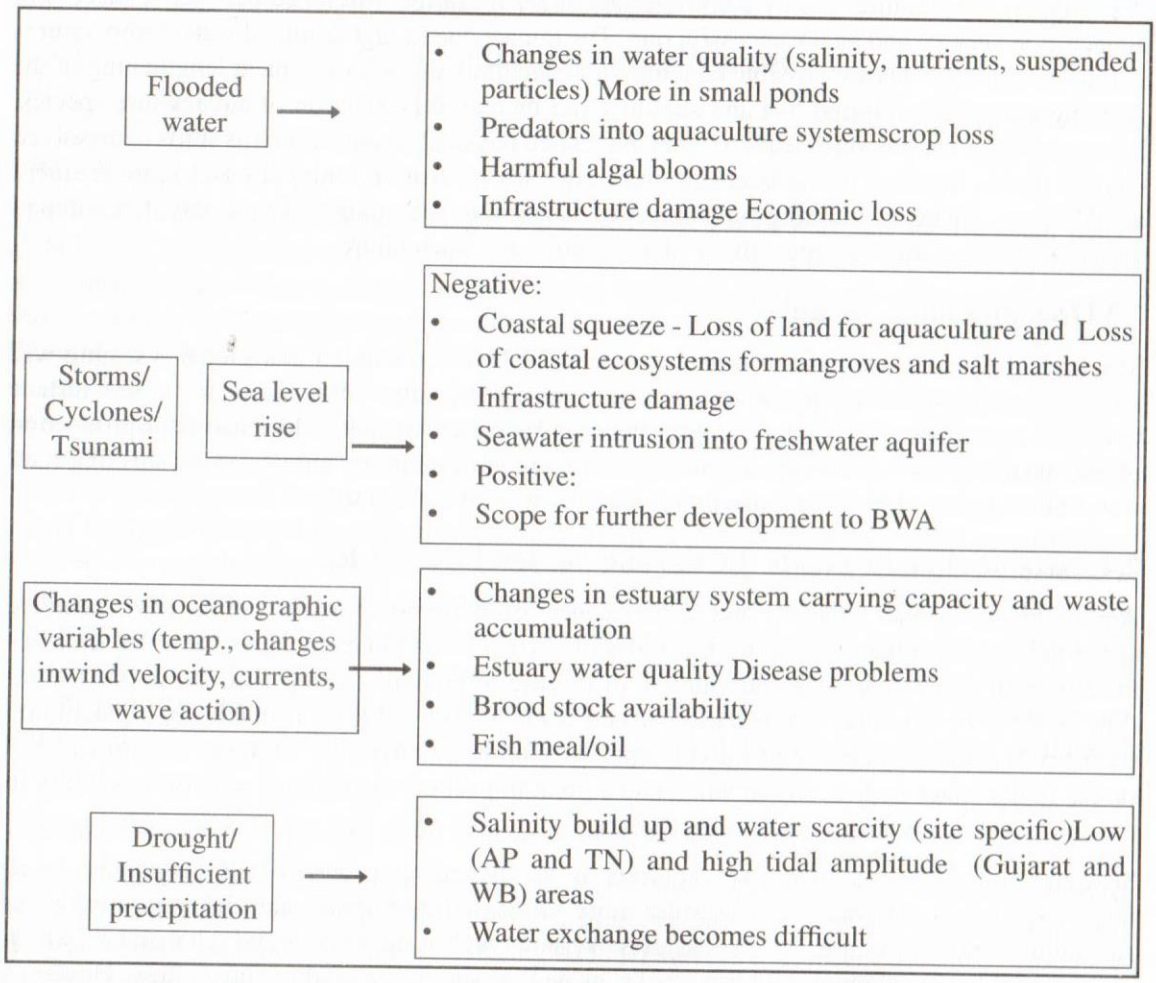
Any increase in the intensity and/or frequency of extreme climatic events have negative consequences for aquaculture in terms of loss of stock, damage to aquaculture facilities, changes in salinity of pond water and, introduction of disease or predators along with the flooded water (Fig.1). Loss of land due to inundation would leads to reduced area available for aquaculture. Changes in estuary systems and shifts in species abundance affect the wild fish recruitment and stocks in the water bodies. Droughtalso had a great impact on aquaculture and rise in salinity in the drains will leads to drop in the culture area.

Seawater intrusion into freshwater aquifers is an increasing problem with rising sea level. Higher sea levels may make groundwater more saline, harming freshwater fisheries, freshwater aquaculture and agriculture, loss of coastal ecosystems such as mangroves and salt marshes, which are essential to maintaining wild fish stocks, as well as supplying seed to aquaculture. However, rising sea levels lead to expansion of areas suitable for brackish or saltwater aquaculture such as shrimp and mud crab. The extent of submergence reported in the Andaman & Nicobar Islands after 2004 tsunami was about 3 m at Indira Point at the southern tip of the Nicobar Islands, and about 1 m at Port Blair in South Andaman Island. Survey by CIBA revealed that around 829ha of seawater inundated areas in the Islands are suitable for brackishwater aquaculture.

3. Studies conducted by ICAR - Central Institute of Brackishwater Aquaculture (CIBA)

CIBA in association with National Centre for Sustainable Aquaculture (NaCSA) implemented an International project "Strengthening Adaptive Capacities to the Impacts of Climate Change in Resource-poor Small-scale Aquaculture and Aquatic Resources-dependent Sector in the South and South-east Asian Region" (Aqua Climate), coordinated by Network of Aquaculture Centres

in Asia-Pacific (NACA), and currently involved in National Initiative on Climate Resilient Agriculture (NICRA) project of ICAR.



3.1 Perception of aqua farmers to climate change events

CIBA has developed a three stage methodology to assess the CC events, perceived impacts, risk assessment, adaptations and mitigations. The investigations were conducted in one climate risk prone district of each coastal state of India considering the traditional and scientific systems of aquaculture being practiced in the respective states. The impacts of climate change not affected aquaculture in all the areas or indeed all aquaculture farmers, in the same way. The climate change events as perceived by the farmers in terms of their experience over the years and their likelihood, impact and risk levels indicated thatunusual high temperature including extreme diurnal variations was the major climate extreme perceived by majority of the aqua farmers (85.6%) and negatively impacted the aquaculture with 20-25% loss or similar level of increased cost of production to follow adaptation measures like top up of water, application of water probiotics, providing adequate aeration and shade, which increases per unit cost of production. Torrential rains with high intensity and flash flood was perceived by majority of the respondents (68.3%

and 66.4%). The likelihood of these extremes was certain to regular and the impact was very high with maximum risk. Cyclones were the other extreme event perceived by about 40.83% of the respondents. Shrimp aquaculture is moderately vulnerable to seasonal variations (20-40% loss) and highly vulnerable to extreme climatic events (50 to 100% loss) like flood and cyclone.

3.2 Damage assessment due to extreme climatic events

Floods, droughts, and cyclones are the main extreme climatic events in tropical Asia and any increase in the intensity and/or frequency of these can damage brackishwater aquaculture.The actual damage to aquaculture due to Cyclones viz.,Nisha in coastal Tamil Nadu (2008), Aila in West Bengal (2009), Laila in Prakasam District, AP (2010), Thane in CuddaloreDist, TN (2012), Phailin in Odisha (2013); Krishna River Flood in AP (2009) and Tsunami (not an ECE) in 2004 was assessed in association with State Fisheries Department. The perception of stakeholders indicated that damage assessment was not proper for getting relief from the Government, crop insurance and bank loan.

It was observed that the actual damage assessed through the interviews and further calculations was higher than the Fisheries Department figures as they have used the norms and rates of Calamity Relief Fund (CRF), where the damage was mentioned to fish ponds, and the investment was very less compared to shrimp ponds. The damage due to cyclone Aila was assessed based on the actual loss to the standing crop, civil structures and employment for Sandeshkhali –II block in West Bengal.The total loss was Rs. 15 crores and even if the employment is considered to be met from family labour, the loss would be Rs. 7.9 crores which was much higher than the figures of CRF rates of Rs.6000/ha for pond desiltation and Rs.4000/- per ha for inputs subsidy coming to a total amount of Rs. 2.85 crores.

3.3 Lessons learned from the response of various stakeholders

Interactions with different stakeholders (farmers, NGOs, Government officials) revealed that aqua farmers are in immediate need of relief in terms of materials like lime and bleaching powder for disinfection of ponds and subsidy for seeds and feed to start culture operations. Relief in cash is required to increase the height of the wall surrounding the farm site, to repair other infrastructure, pumping of saline water out of ponds and repair of embankments. Sometimes data collected by various agencies of Government are mutually contradictory and hence there is necessity to develop clear guidelines for validation of the data. Relief/ Disaster Management Departments in the States should be the nodal points for collection of such data from the districts and nodal Departments, while the Directorate of Economics and Statistics shall facilitate the collection of such data and finally compiling them for presentation to the concerned departments. With respect to fisheries and aquaculture, the data is collected by State Fisheries Departments and there is no uniformity in the collection of data by the Department Officials from one region to the other. Uniform formats and clear guidelines for collection of data should be developed to avoid any confusion among the data collection agencies. Available data sets should be analyzed with the help of charts, diagrams etc. for the benefit of the users.

The data on area under cropping prior to ECE is very important to undertake relief measures. The Fisheries department should have this data for every crop immediately after stocking just

like agriculture. Since this data is not available in many instances, the damage assessment and the relief measures are getting delayed. Many shrimp aquaculture farmers do not have the farms license issued by Coastal Aquaculture Authority and the relief is being given only to the farms having license. Political interventions and pressures should be avoided on administrative officials assessing the data.Crop calendar is not followed systematically in many places and this has to be considered as utmost important in order to assess the damage in case of ECEs. If crop calendar is followed properly like agriculture, then it will be easy to calculate the farming area under culture before ECEs.

3.4 Suggested approach to study the impact of extreme events on aquaculture

After the occurrence of ECE, the damage assessment should be done immediately and systematic through questionnaire interviews and focus group meetings with various groups like farmers, fishermen, hatchery owners, village Panchayat leaders, input dealers, commission agents, NGOs and Govt. officials etc. Latest technological tools like remote sensing and GIS should be used for the accurate estimation of damage. Changes in water and soil quality after ECEs in aquaculture areas have to be investigated. Photographic evidence of the damages should be captured wherever possible for showing to team members who will be visiting for the damage assessment at a later date. The input from studies on various ECSs should also be used to develop models that can be used to arrive at damage losses assessment due to future ECEs.

3.5 Existing relief measures and suggestions for modifications

In the reports of Natural Disaster Management Division and Ministry of Agriculture, the losses due to ECEs were reported generally in terms of population affected, damage to agriculture crop area, livestock population and the estimated value but not mentioned about losses to aquaculture. In the proforma of disaster management Division on daily report on rainfall and flood also, damage to aquaculture is not covered. Since the types of damage to aquaculture are different, unless these are reflected in the proforma used for assessing the damages, the actual extentof damage to aquaculture would not get recorded.

The immediate relief measures required for the shrimp aquaculture farmers include grant of emergency relief to all the affected people, commencement of aquaculture activities such as desilting and dewatering of the inundated ponds, repairs and reconstruction of infrastructure facilities such as approach roads to aquaculture farms, pond dykes, diesel pumps, electric motors and electrical supply lines, pond preparation, seeds for restocking and chemicals like bleaching powder and lime. Immediate repair of damaged source waters and piping or rat holes in embankments with the use of cement, sand bags and stones, and removal of vegetative material and debris from the common feeder canals and drainage channels in shrimp farming areas has to be attended.

It has been mentioned in the calamity relief fund (CRF) assistance to fishermen for the repair of crafts and nets separately. Assistance is being given to small and marginal farmers @Rs.6000/ha for desisting desilting/restoration of fish farms. Assistance in terms of agricultural input subsidy is mentioned to agriculture, perennial, horticultural and plantation crops when 50% of crop loss was observed. Animal husbandry was mentioned separately for animal loss, feed, water supply, additional cost for medicines and vaccines. Input subsidy for fish farms is mentioned @ Rs.4000/

ha. As on today shrimp farming is considered on par with fish farming and the relief subsidy earmarked for fish farms is applicable to shrimp farms also. But shrimp aquaculture is more capital intensive enterprise with more infrastructure requirement such as hatcheries for seed supply, dykes, electric motors diesel pumps and inputs such as feed, fertilizers, chemicals and probiotics in the culture ponds, processing plants for the storage of harvested shrimp and further to export the product unlike fish farms and hence the relief subsidy should be considered separately.

4. Mitigation and adaptation measures

There is no universally applicable list of mitigation practices and the practices need to be evaluated for individual agricultural systems and settings, which is also applicable to aquaculture. India is vulnerable to the effects of global climate change, and is coming under increasing pressure to put strategies in place to adapt to, if not mitigate, climate change. The less mitigation we do now, the greater would be the difficulty of adapting in future. The autonomous adaptation measures need to be taken up at the farmer's level and the planned adaptations are to be undertaken by planners, development departments and research institutions. For example, the problem of water scarcity and higher salinity is very site-specific with wide variations depending on the tidal amplitude, water current and inflow of freshwater. Hence the strategic plans should vary according to the conditions of the site. With reference to drought conditions and low water availability due to delay in monsoon and under high temperature conditions, the following are the general guidelines or autonomous adaptations to improve the water quality.In areas more prone to higher frequency and/or intensity of storms, remedial measures should be incorporated during the site selection, designing and construction of farms. The most important planned adaption measures need to take up in the aquaculture clusters by the government agencies are periodical dredging of water canals, opening of bar mouth and proper roads to carry the materials. Adaptation options in aquaculture are best addressed when they are incorporated in integrated coastal management and sustainable development plans. The fisheries research institutes need to prepare guidelines for providing relief, institutional credit and insurance to aquaculture during the times of extreme climatic disasters. The National Mission on Agriculture, one of the eight missions set up by the Government of India to deal with climate change issues do not refer to fisheries and aquaculture specifically. The sector was not supported with institutional credit and insurance due to high risks and higher coverage. While agriculture was given institutional support and compensation in case of climate change extreme related losses, aquaculture was not considered for the same. Some of the planned adaptation strategies in general and relevant to the aquaculture are:

- Common dyke and flood wall construction in aquaculture farms location, where floods are common would help reduce loss.
- Pre-monsoon inspection of all the canals and drains by respective Departments
- Regular maintenance of embankments of rivers, canals, distributaries etc.
- Raising awareness of the importance of mangrove systems and green belt plantations that acts as bio-shield.
- Construction of saline embankments for protection against sea water ingress
- Construction of multi-purpose storage structures for the protection of farm inputs.

- Capacity building and establishment of institutions to manage the expected changes.
- should be used for the accurate estimation of damaged area
- Implementation of better management practices (BMPs) and use of Ecosystem approach to aquaculture (EAA) in the planning process.
- Micro zonation vulnerability maps (cyclone and flood hazard maps) and early weather warning systems for aquaculture.

5. Policy measures required for aquaculture

The climate change policies have to be integrated with sustainable development strategies in general, and poverty alleviation measures, in particular. This will make the problem of adaptation more continual in nature. A greater attention is required from policy makers on the part of policy formulation. The following are the few policy mesures to be considered for aquaculture.

Aquaculture vulnerability has to be prepared similar to agriculture. Assessment of the aquaculture resources available in the country and derive the plans based on the available resources from the satellite data and identify the suitable sites with buffer zone incorporating soil and water resources.

In the assessment of damage due to ECEs, aquaculture subject has to be considered separately like agriculture and livestock in all the assessment proformas and also in CRF proforma and relief measures should be suggested separately.

Geographical information system (GIS analysis) is being used to assist authorities in identifying the areas where mitigation effort should be concentrated. GIS database will assist in hazard zonation, risk assessment, preparedness and emergency response management in relation to aquaculture.

In terms of responding to ECEs, shrimp aquaculture should be integrated into coastal zone management (ICZM) that can be seen as an essential institutional mechanism to deal with all competing pressures on the coast, including short, medium and long-term issues.

Conclusions

The existing pressures of demand on coastal aquaculture production and anticipated challenges will require better multi-scale understanding of the impacts of climate change impacts, both positive and negative consequences along with possible strategies to counter them.Actions are urgently needed to mitigate the factors driving climate change, as well as to adopt adaptation measures aimed at countering the threats to food and livelihood provision. Adaptive tools for the aquaculture sector will need to be refined, and implemented to guide decision making under uncertainty. A very strong focus on building general adaptive capacity can help the aqua farming communities to cope with new challenges and become climate resilient. In the face of potential complexities of climate change interactions and ECEs and their possible scale of impact and the existing development and management constraints, the primary challenge for the aquaculture sector will be to deliver food supply, strengthen economic output and maintain and enhance food security. Fisheries and aquaculture need to be adequately addressed in climate change policies and programmes dealing with global commons, food security and trade and also in the decisions

related to climate change in the other major sectors. Increased awareness amongst policy-makers and consumers about the importance of aquaculture in national economy and the extent of damage to the sector due to ECEs is required. Responses will need to employ integrated ecosystem-based approaches to fisheries and aquaculture for the national aquaculture sector throughout the entire resource extraction, supply and value chain.

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