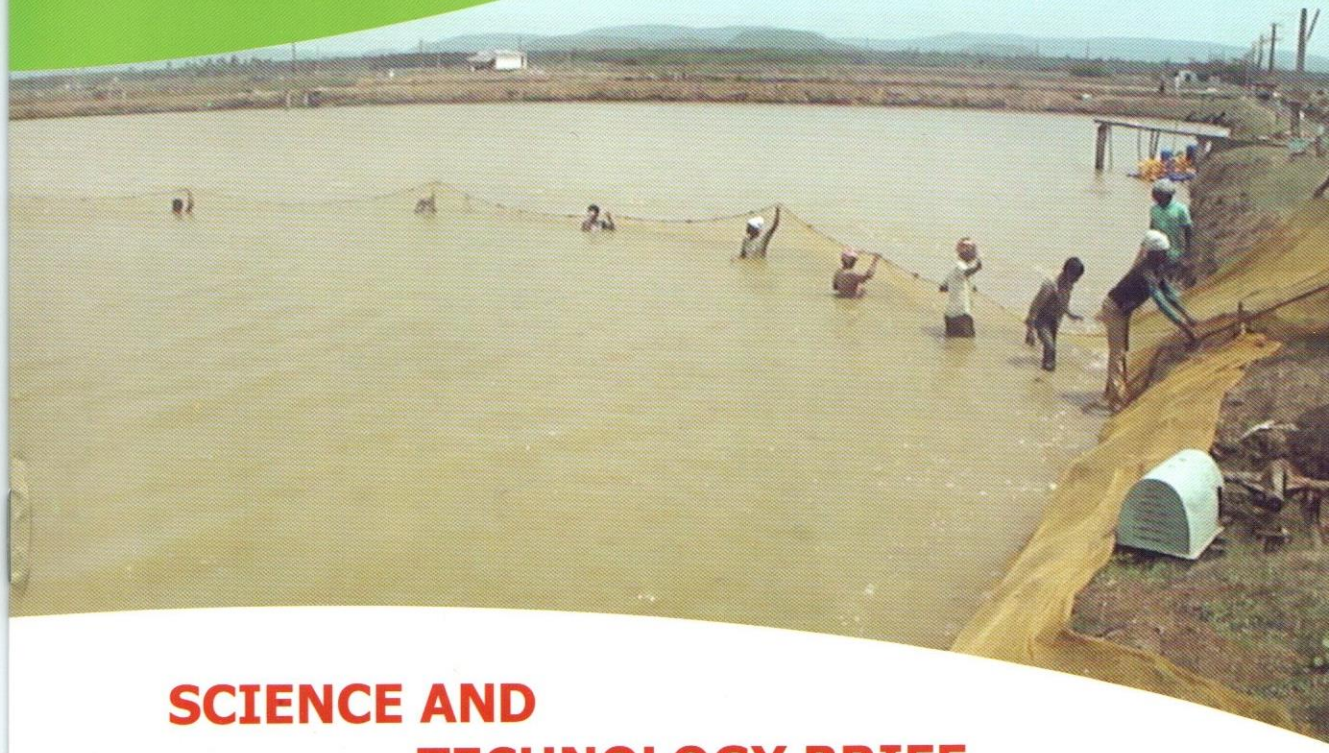
Vulnerability and adaptation to climate change for shrimp farming in India: Science and technology adaptation solutions



SCIENCE AND TECHNOLOGY BRIEF

SCIENCE AND TECHNOLOGY NEEDS

- INCREASE ACCURACY IN PREDICTIONS OF WEATHER PARAMETERS AND EXTREME CLIMATIC EVENTS AND DEVELOPING GUIDELINES FOR THE ASSESSMENT OF LIKELY DAMAGE: Forecasts need to be improved to address sudden seasonal shifts and changes and to be downscaled to district and lower administration unit levels. Guidelines have to be developed on damage assessment to aquaculture due to extreme climatic events.
- DEVELOP FORECASTS ON WATER AVAILABILITY IN BOTH FRESH AND BRACKISHWATER BODIES AND CHANGES IN SALINITY REGIMES: Accurate local forecasting will help planners and farmers develop mitigation and adaptation strategies for shrimp farmers.
- IDENTIFY VULNERABLE COASTLINES AND ESTABLISH SUITABLE MANGROVE SPECIES TO PROVIDE SHELTER BELTS AND BARRIERS: Location specific mangroves have to be recommended for plantation as barrier to protect the shrimp farms against cyclones/storm surges and sea level rise.
- IDENTIFY ALTERNATIVE SPECIES THAT CAN TOLERATE EXPECTED ABIOTIC STRESSES SUCH AS SALINITY AND TEMPERATURE VARIATION AS A CONTINGENCY: New culture technologies for alternative species that can tolerate the expected changes in environmental parameters and that can provide diversification options for farmers under different climatic regimes have to be developed.
- MAKE INVESTIGATIONS ON THE SEASONAL CROP PATTERN, ANIMAL BEHAVIOUR, POND DYNAMICS AND ECOSYSTEM IN RELATION TO CLIMATE CHANGE AND EXTREME CLIMATIC EVENTS: Studies on changes in shrimp physiology, pond dynamics and productivity including plankton diversity and water quality parameters as they relate to climate change will assist in giving appropriate crop calendar and management recommendations.
- INVESTIGATE WEATHER ANOMALIES THAT MAY TRIGGER DISEASE OUTBREAKS AND THE IMPACT OF CHANGING SEASONAL PATTERNS ON EMERGENCE OF NEW DISEASES: Disease occurrence patterns are likely to change in relation to changing weather conditions and climate. These changes must be studied in order to develop new management strategies and interventions.
- RESEARCH INTERVENTIONS ON BETTER MANAGEMENT PRACTICES IN THE CONTEXT OF CLIMATE CHANGE: Technologies for engineering structures to strengthen farm peripheral dykes, improved feeding and fertiliser management protocols and similar must be standardised and to be popularised amongst farmers.
- ESTIMATE OF ACTUAL AERATION REQUIREMENTS AND IMPROVE THE EFFICIENCY OF PUMPING AND AERATION: Increasing the efficiency of aerators and pumps and avoiding unnecessary excess energy usage will help in reducing production cost and in decreasing the carbon foot print from shrimp aquaculture.
- DEVELOP LOW FISH MEAL FEED TECHNOLOGY USING PLANT PROTEIN SOURCES: As the availability of fish meal and fish oil is expected to decline, and may also be impacted by climate change, research on alternative protein sources is an immediate requirement for the feed manufacturing industry to reduce the cost of feed.
- DEVELOP AWARENESS MATERIALS ON CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES AND PILOT A CLIMATE CHANGE FIELD SCHOOL CONCEPT: Information on climate change impacts in aquaculture and adaptive measures needs to be made available to all stakeholders and farmers preferably in local languages. The concept of a climate change field school as implemented in other countries should be investigated for implementation in India.

SHRIMP FARMING AND CLIMATE CHANGE

This brief summarises the results from the interdisciplinary and multi stakeholder participatory study conducted within the Aquaclimate project in Krishna District, Andhra Pradesh, India, looking at the impacts of climate change and adaptation measures in the shrimp farming sector. The brief based on scientific analysis and stakeholders inputs, further provides science and technology solutions to be undertaken for improving farmers' adaptive capacity to climate change.

Impacts of climate change on shrimp farming

The study area is vulnerable to sea level rise in future and has been included under high-risk category. The coastal areas have experienced many weather related impacts in recent years, including the most severe drought in 50 years which occurred early- to mid-2009, followed by a severe once in a century flood event in the Krishna River during October 2009. These extreme weather events had severe consequences including heavy economic losses to shrimp farmers in the state.

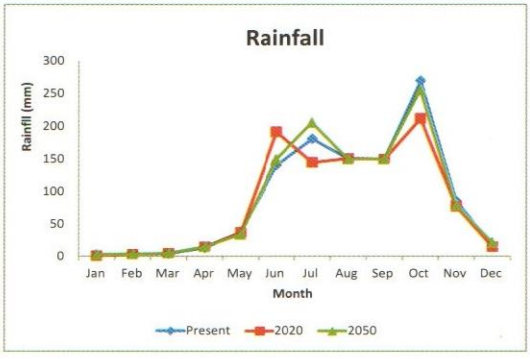
Farmers and stakeholders in the study area perceived that climate change had induced extreme weather events such as drought, storms and floods and variations in climatic parameters such as temperature and rainfall, which posed a threat to shrimp farming and would potentially lead to production losses. Variability in the amount of rainfall under different scenarios of monsoon and changes in temperature could negatively impact aquaculture through changes in water quality and greater incidence of disease.

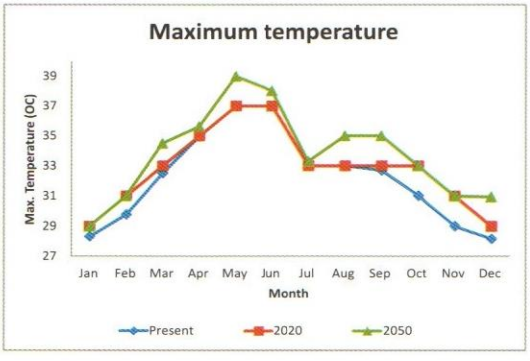
The impacts of climate change on shrimp farming could occur directly or indirectly and cannot be attributed to one single factor of climate change. The likelihood and consequence ratings for each climate change event as expressed by stakeholders consulted during the project indicated that floods and seasonal weather variations pose the highest risks to shrimp farming, with heavy rain and cyclones considered a medium risk.

Irregular seasonal variations affect water salinity, pH, oxygen levels resulting in higher disease incidence, lower feed intake and slower growth. Heavy rainfall causes a reduction in salinity, pH fluctuations, reduced dissolved oxygen and higher disease incidence. High temperature results in increased pH and salinity, low water availability in source waters and a decline in dissolved oxygen levels and algal bloom development. Flooding is associated with water pollution and an increase in viral infections and death of shrimps due to rapid oxygen depletion. Cyclones with heavy rains lead to flooding and cause contamination across the ponds.

The predicted future climatic scenarious for 2020 and 2050 indicated that the average maximum and minimum temperatures will increase throughout the year and the rainfall is not expected to change much from the presents level.

The current knowledge of the impacts of climate change on shrimp farming is insufficient to fully inform mitigation and adaptation measures for farmers. There is an immediate need to find science





and technology solutions to improve the adaptive capacity of farmers and to provide climate resilient production strategies.

The Aquaclimate Project is a three year initiative to strengthen the adaptive capacities of rural farming communities to the impacts of climate change. The project focuses on small-scale aquaculture in Vietnam, the Philippines, India and Srilanka. This brief provides a summary of the project's work with tiger shrimp farmers in the Indian case study area, Krishna District in Andhra Pradesh. It highlights the science and technology solution to be undertaken for improving farmers adaptive capacity and to sustain the industry and its contribution to the livelihoods of poor farmers and food security. The project was coordinated by the Network of Aquaculture Centres in Asia-Pacific and funded by the Ministry of Foreign Affairs, Norway, through the Royal Norwegian Embassy, Bangkok; and undertaken by international partners Bioforsk (Norway), Akvaplan-niva (Norway), Kasetsart University (Thailand) and local case study partners. The local partners for the tiger shrimp case study were the Central Institute of Brackishwater Aquaculture of the Indian Council of Agricultural Research, in conjunction with National Centre for Sustainable Aquaculture, affiliated with the Marine Products Export Development Authority.

SCIENCE & TECHNOLOGY

Farmers can adapt to small changes in weather patterns and short term gradual climate change but they are not prepared for rapid changes or long term continuous climate change. Farmers need to be assisted by scientific research and technology development to find solutions that will allow them to adapt to the predicted future climate change.

There is a need for scientific research to understand the underlying biological processes that are affecting productivity due to climate change and develop potential solutions for farmers. In addition, there is a need for scientific research to accurately understand climate change and its potential impacts to support the decision making by central, regional and local governments.

The new adaptation technologies will need to be cost effective, environmentally sustainable, culturally compatible and socially acceptable. The technologies will also need to be implemented which will require widespread technology transfer supported by effective institutions, both formal and informal. Funding will need to be identified to support the necessary research and technology development.

The role of science and technology

Scientific research and technology development can play a strong role to support farmers in developing new adaptation measures to predicted future climate change as well as developing standardised methodology for assessing socio-economic vulnerability of communities and culture systems, and developing adaptation measures.

Science and technology solutions

Even if new technologies are devised, and are suitable for local conditions, it can be difficult for the poorer farmers to adopt them. With small farm sizes and limited access to credit, they may have neither the ability nor the inclination to invest in new technology.

Whatever the envisaged levels of technology, it is clear that there is a need to devise national strategy for adaptation, assessing the communities and the locations at greatest risk and planning appropriately. Scientific forecasts and warnings may not yet provide the level of precision desired by many planners, but they portray with certainty a rapidly warming world with consequences that globally, and for most sectors, are largely negative. A new climate is on the way. Adaptation is not a choice, it is a necessity.

Technologies for adaptation

Many of these technologies are already available and widely used and it should be possible to adapt to some extent by modifying or extending existing technologies. These measures are mainly refinement of the existing or innovation of new technologies to adapt the shrimp farming to the forthcoming climate change events. The important measures are improvement of better management practices, identification of alternate species for aquaculture and the development of technology, scientific principles in planning mitigation measures such as mangrove plantations, de-silting and deepening of drains, and construction of flood walls.

SCIENCE & TECHNOLOGY ADAPTATION MEASURES

Increase accuracy in predictions of weather parameters and extreme climatic events and developing guidelines for the assessment of likely damage

Presently the available climate change forecasts on weather parameters are average monthly values and available for larger geographical areas. There are no proper guidelines for the assessment of damage with respect to the infrastructure and standing crop

during extreme climatic events. This information will be useful to link with the district level weather data generated by the India Meteorological Department to give agro-advisory services to the farmers.

- Forecasts on temperature and precipitation have to address the seasonal shifts and sudden changes and to be downscaled to district and lower administration unit levels.
- Guidelines for the assessment of likely damage due to extreme climatic events should be developed.

Develop forecasts on water availability in both fresh and brackishwater bodies and changes in salinity regimes

It is predicted that changes in availability and quality of source water including the salinity profile in relation to weather parameters will affect shrimp production.

- Provide forecasts on source water quantity and quality to help planners and farmers to develop mitigation and adaptation strategies.

Identify vulnerable coastlines and establish suitable mangroves species to provide shelter belts and barriers

It is essential to identify vulnerable areas of coast line where aquaculture may be affected by extreme weather events so as to plan effective mitigation measures. There are instances of degeneration of mangrove plantations on river banks and coastal areas due to incorrect choice of mangrove species. Therefore there is a need for research to identify the correct species for planting and for creating defence structures to protect vulnerable coastal areas against cyclones and storm surges.

- Undertake GIS analysis of storm surge vulnerability along the coast to identify vulnerable coastlines and most suitable areas for mangrove planting.
- Research on the vulnerability, bathymetry and topography slope analysis, fetch and wind /wave analysis to assist in the identification of areas most suitable for mangrove planting.
- Research institutes with the help of the M.S. Swaminathan Research Foundation should identify suitable mangrove species in the buffer zone between the shrimp farms and on the river beds along the coast.
- Appropriate coastal defense structures should be designed with the assitance of the Engineering Departments in reputed Institutes.

Identify alternative species that can tolerate expected abiotic stresses such as salinity and temperature variation as a contingency

It is forecast that pond water temperatures will increase and pond salinity will fluctuate more widely. Larger saline areas are expected to increase under climate change scenarios. Studies by the Central Institute for Brackishwater Aquaculture indicate that land shaping after Cyclone Aila in West Bengal provided aquaculture livelihood opportunities to the agricultural farmers whose lands had become saline. The shrimp species *Litopenaeus vannamei* is already being cultured over a wide range of salinities from very low to hyper saline waters, though their growth is suboptimal at both extremes. Fresh water species such as the Indian Major Carps are being cultured under low salinities. Paddy cum fish culture should be encouraged in line with predicted climate change.

- Investigate saline tolerant paddy varieties suitable for integration with aquaculture species.
- In cyclone affected areas, explore tidal inundated sites which cannot be used for agriculture for possible utilisation in brackishwater aquaculture.
- New culture technologies for alternative species that can tolerate the expected changes in environmental parameters and that can provide diversification options for farmers under different climatic regimes have to be developed.
- Proposed crop calendar activities should be provided by Government for the adaptation by the farmers.

Make investigations on the seasonal crop pattern, animal behaviour, pond dynamics and ecosystem in relation to climate change and extreme climatic events

It is predicted that changes in temperature and rainfall patterns will affect the productivity of ponds and changes in water quality through the variation in salinity, pH and oxygen levels. High temperatures also prolong the crop duration due to low feed intake and poor growth. The quality of water sources may also be affected and it is necessary to understand the basic principles underlying these aspects. Research Institutes with the help of fisheries colleges and the Department of Fisheries should undertake research on the following aspects in relation to climate change:

- Physiological aspects of shrimp behaviour in terms of feeding metabolism and reproduction.
- Tidal amplitude and changes in water source quantity and quality parameters and pond

water parameters through water quality monitoring in selected areas to identify seasonal variations and to correlate with the changes in weather patterns.

- Pond dynamics and productivity including plankton diversity.
- Impact of high temperature and rainfall on shrimp productivity.

Investigate weather anomalies that may trigger disease outbreaks and the impact of changing seasonal patterns on emergence of new diseases

A rapid change in water quality and weather parameters can lead to a higher incidence of disease. Hence, disease occurrence patterns in relation to changing weather conditions should be studied in order to understand the mechanisms underlying the incidence of existing and emerging diseases.

- Conduct epidemological investigations to understand the relationship between weather disturbances and diseases incidence.
- Research Institutes in association with other organisations should arrange regular monitoring of pathogens and shrimp disease outbreaks and provide recommendations on prevention and treatment to the farmers.

Research interventions on better management practices in the context of climate change

The effectiveness of existing BMPs in the context of climate change needs to be investigated, with specific reference to developing new BMPs such as pond designs to withstand extreme climatic events, forecast changes in water quality and increased disease incidence due to weather disturbances. Such BMPs need to be popularized as adaptive measures among the farmers. Research Institutes in association with the National Centre for Sustainable Aquaculture and fisheries colleges should undertake these studies on the following areas:

- Standardisation of feeding practices and fertiliser management and liming protocols.
- Maintenance of water levels and topping -up.
- Oxygen enhancers.
- Engineering farm design with reference to site specific calamities and natural disasters.
- Reservoir maintenance and water treatment.

Estimate of actual aeration requirements and improve the efficiency of pumping and aeration

Pumping and aeration are required to maintain water level and quality parameters in acceptable ranges. The need for top up or water exchange varies with temperature, rainfall and weather conditions. Similarly more aeration is required during cloudy days or under heavy rainfall. Studies by the Central Institute for Brackishwater Aquaculture have indicated that farmers are using more aeration than is actually required. The energy consumption for the operation of motor pumps and aerators are high and contribute to high power consumption.

- Estimate the actual aeration requirement to avoid unecessary and excessive use of aerators.
- Improve the efficiency of aerators and pumps through mechanical interventions by Aquaculture Engineering Departments. This will help in reducing the production cost for farmers and also in decreasing the carbon foot print from shrimp aquaculture.

Development of low fish meal feed technology using plant protein sources

The availability of fish meal and fish oil is expected to decline due to competition from other sectors and supplies may also be affected by climate change. Alternative protein sources must be found to meet the growing requirements of the feed manufacturing industry and to reduce the cost of feed.

- Intensify research on development of low fish meal feed technology using plan protein sources and popularisation of this feed technology among farming communities.

Develop awareness materials on climate change impacts and adaptation measures and pilot a climate change field school concept

There is a lack of awareness and understanding on climate change by shrimp farmers particularly of predicted future climate change and potential adaptation measures.

- Research Institutes with the help of other organizations should collect science based resource materials and then prepare training materials on present and future predicted climate change, potential adaptation and mitigation measures for aquaculture.
- The training materials should be preferably translated into local languages and made available to all stakeholders. The training materials should be updated regularly as climate science research and lessons learned from adaptation measures developed elsewhere are developing rapidly.
- Research Institutes should arrange 'train the trainer' programmes aimed at trainers/ technicians who in turn will train farmers (actual operators and caretakers).
- Pilot the Climate Field School concept being followed in other countries such as the Philippines, and improve based on feedback from participants.

SUMMARY OF RECOMMENDATIONS FOR KEY STAKEHOLDERS

Stakeholder group	Recommendations
Government Research Institutes such as the Central Institute of Brackishwater Aquaculture, State Institute of Fisheries Technology, Fisheries Colleges, Aquaculture Engineering Department at IIT.	Undertake specific research in relation to climate change on: • Pond dynamics and productivity • Water quality changes and monitoring • Low fish meal feed technology using plant protein sources • Location specific culture technologies such as diversification of suitable economic and viable species under different climatic regimes • Interventions on better management practices in the context of climate change • Improving the pumping and aeration efficiency • Epidemological investigations on new disease incidence • Identifying suitable mangrove species for bio-shields and buffer zone • Identifying vulnerable coastal areas for aquaculture
Forecasting organisations such as the Indian Meteorological Department and Central Water Commission	• Accurate predictions on seasonal shift and sudden changes in weather parameters and water availability in source waters • Downscaling of predictions to district level
Research Institutes and Fisheries Colleges	• Development of training curriculums, and training materials and facilitating training and capacity building for fisheries extension officers and technical consultants
Training Institutes such as Regional Fisheries Training Colleges, M.S. Swaminathan Research Foundation, National Centre for Sustainable Aquaculture.	• Undertake training courses on adaptation and mitigation measures to increase the adaptation capacity of farmers

Stakeholder Workshop at Vijayawada, Krishna District, Andhra Pradesh.

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