Climate Resilient Technologies/Practices to Support Pond Aquaculture and Beel Fisheries under APART

Assam, India

ARIAS Society
GOVERNMENT OF ASSAM
Assam Rural Infrastructure and Agricultural Services Society

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Assam, India

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Abbreviations and Acronyms

AAU	Assam Agricultural University
ADAPT	Analyze-Develop-Assess-Prioritize-Tackle
AFDC	Assam Fisheries Development Corporation
APART	Assam Agribusiness and Rural Transformation Project
ARIAS	Assam Rural Infrastructure and Agricultural Services Society
AYUSH	Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homeopathy
BDC	*Beel* Development Committee
BISA	Borlaug Institute for South Asia
BMP	Best Management Practices
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research

CIFA	Central Institute of Freshwater Aquaculture
CIFRI	Central Inland Fisheries Research Institute
CIFT	Central Institute of Fisheries Technology
CIMMYT	International Maize and Wheat Improvement Center
CoF	College of Fisheries
CSIR	Council of Scientific and Industrial Research
DoF	Department of Fisheries
EPO	European Patent Office
FGD	Focus Group Discussion
FIG	Farmer Interest Group
FPC	Farmer Producer Company
FPG	Farmer Producer Group
GI	Geographical Indication
ICAR	Indian Council of Agriculture Research
IEK	Indigenous Ecological Knowledge
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
IK	Indigenous Knowledge
IMC	Indian Major Carp
IMD	India Meteorological Department
IPR	Intellectual Property Right
IRRI	International Rice Research Institute
ISRO	Indian Space Research Organisation
ITK	Indigenous Technical Knowledge
KAP	Knowledge-Attitude-Practice
KII	Key Informant Interview

KVK	Krishi Vigyan Kendra
MFIs	Microfinance Institutions
MoU	Memorandum of Understanding
NABARD	National Bank for Agriculture and Rural Development
NBFGR	National Bureau of Fish Genetic Resources
NFDB	National Fisheries Development Board
NGO	Nongovernmental Organization
NIFPHATT	National Institute of Fisheries Post harvest Technology and Training
NRSC	National Remote Sensing Centre
PDO	Project Development Objective
PMMSY	Pradhan Mantri Matsys Sampada Yojana
PoP	Package of Practices
PRA	Participatory Rural Appraisal
RAS	Recirculation Aquaculture System
RBA	Rastriya Barh Ayog (National Flood Commission)
SAPCC	State Action Plan on Climate Change
SDGs	Sustainable Development Goals
SOP	Standard Operating Procedure
SWOT	Strengths-Weaknesses-Opportunities-Threats
TEK	Traditional Ecological Knowledge
TKDL	Traditional Knowledge Digital Library
ToR	Term of References
TRIPS	Trade-Related Aspects of Intellectual Property Right
UNESCO	United Nations Educational, Scientific and Cultural Organization
USPTO	United States Patent & Trademark Office
WBUAFS	West Bengal University of Animal & Fishery Sciences

Weights and Measures

°C	degree Celsius
BCM	billion cubic meters
cm	centimetre
crore	ten million
g	gram
ha	hectare
kg	kilogram
Km	kilometre
Km^2	square kilometre
lakh	hundred thousand
m	meter
mm	millimetre
MT	metric tonnes (1000 kg)
ppt	parts per thousand

Note

₹	Indian Rupees (Rs.)
$	US dollar

Executive Summary

In North-East India, Assam is the largest state in population and second in terms of area. It shares about 2.4% of the country's total geographical area and provides shelter to 2.6% population of the country. The Brahmaputra and Barrak rivers along with their tributaries and numerous flood-plain wetlands give a distinctive hydro-geomorphic feature to the region. Being blessed with huge fishery resources and having the excellent tropical climate with average annual rainfall of over 1500 mm, Assam is undoubtedly one of the most potential states in India for the development of fisheries. Fish is also the staple food of the Assamese people. Despite of the favourable geo-social environment, the development of fisheries sector in Assam has not been impressive till recent past. One of the probable reasons for this is the vulnerability of the state to the climate induced hazards like flood, erosion, drought, etc. which are adversely impacting the fishery sector of the state. In the year 2018, the state has launched World Bank assisted 'Assam Agribusiness and Rural Transformation Project (APART)' with fisheries as a sub-component. Through this project, WorldFish is extending the technical support to the state with its international experience and expertise. One of the focus areas of WorldFish is climate-proofing the fishery sector of the state by developing and promoting climate-resilient technologies. The purpose is to counter the negative impacts of climate change, mainly the pond aquaculture and Beel fisheries, and to push the fish production of the state upward. The outcome of the present study would support the resilience of fisheries and aquaculture production systems in order to increase fish production and reduce the risks associated with climate change, in the targeted districts of Assam.

The sequential steps followed in the study were: Desk Research → Questionnaire Development for Survey → Conducting Survey → Collation of Information → Formulation of Climate Resilient Technologies & Strategies → Report Submission. The desk research started with a critical review of published reports and statistics on the Climate of Assam, Observed Changes and Projections. In order to check the ground reality and to collect first-hand information, contact was established with the farmers, fishers, scientists, experts, extension functionaries and other stakeholders in nine districts; namely Kamrup (M), Kamrup (R), Barpeta, Nalbari, Morigaon, Nagaon, Darrang, Jorhat and Cachar. This was achieved through questionnaire-based survey, Focus Group Discussion (FGD), Participatory Rural Appraisal (PRA) and Case Studies. Knowledge-Attitude-Practice (KAP) surveys were conducted amongst the 60 numbers of fish farmers in six districts (in-person survey - 30 Nos. and telephonic survey - 30 Nos.) using the pretested questionnaires. Key Informant Interview (KII) covered 20 numbers of well-informed stakeholders like fishery officials, researchers, academicians, experts, etc. who had first-hand information and insight on the issues pertaining to climate change and

its impact on fisheries. Focus Group Discussions (FGDs) were conducted in three areas of activity, such as culture fishery, capture fishery and seed production. Total 12 numbers of FGD were conducted and on an average 10-15 participants took part in each FGD. In order to accomplish the study in a cohesive manner, one PRA and four case studies were included.

Climate Change Trends & Fisheries in Assam

There are three distinct seasons in Assam, i.e., summer, rainy, and winter. The summer season starts from the month of March and extends till the end of June. The average temperature during this time of the year is between 35 and 380C. The rainy season begins in June and often goes on till September. The average annual rainfall in the state is around 175 cm in the west and around 300 cm in the east. The winter season prevails from the month of October to the end of February. India Meteorological Department has undertaken the long-term assessment of the climate change for a 60-year period, during 1951-2010 for Assam. The analysis is based on data collected from 6 Stations for temperature and 12 Stations for rainfall. The analysis indicates that the mean temperature in the State has increased by +0.01 0C/year. There is also an increase in seasonal temperatures across seasons with pronounced warming in post monsoon and winter temperatures. The annual rainfall has also decreased by -2.96 mm/year during the same period.

The flood and erosion problem in Assam is distinctively different from the other Indian states so far as extent and duration of flooding and magnitude of erosion is concerned. It is probably the most acute and unique in the country. The flood problem of the state is further aggravated due to flash floods by the rivers flowing down from states of Arunachal Pradesh, Meghalaya and neighbouring country of Bhutan. The flood prone area of the state as assessed by the Rastriya Barh Ayog (RBA) is 31.05 Lakh hectares against the total area of state 78.523 Lakh hectares (39.58 % of the total land area of Assam as against the national average of 10.2 %).

District level climate projections are available across Assam for the period 2021–2050, based a model developed by UK Meteorological office. It is to be noted that such projections are only indicative in the very broadest sense of the changes with high level of uncertainties. As per the projection, temperatures continue to rise and may increase by 1.7-2.0 0C with respect to base line. Only the western part of the State will experience slight decrease in rainfall but the rest of Assam is projected to have increase in rainfall. There is likely to be increase in extreme rain fall event by 5% to 38% with respect to base line. Drought's weeks are going to rise, with Southern districts showing marginal reduction in drought weeks but rest of the district show an increase by more than 75% with respect to base line. As per the predictions, floods are going to rise by more than 25% in the southern parts of

Assam. The history of land erosion in Assam indicates that between the years 1912 and 1996, around 868 sq. km. of land was lost to bank erosion; averaging to about 10.3 sq. km. of area lost per year. Nevertheless, accretion, the deposition of silt which is concurrent process leading to formation of new area in the north and south banks amounted to 303.84 sq. km and 246.32 sq. km. (total 550.16 sq. km.) respectively. Almost in the entire state of Assam, the groundwater is available at low to a moderate depth. The pH value of ground water ranges from 7.5 to 9.0. All parameters pertaining to groundwater are within the permissible limit except iron, fluoride and arsenic. Fluoride is present only in deeper aquifer. The annual ground water draft in Assam is estimated to be 5.44 billion cubic meters (BCM) of which 4.85 BCM is for irrigation and 0.59 BCM is for domestic and industrial purposes.

Fisheries activities in Assam

Fish occupies a prominent place in the lives and livelihoods of the people of Assam and fish farming is one of the common activities in the rural areas. In Assam, fish comes from two main modes of production systems; aquaculture (farming fish in ponds and tanks) and *beel* fisheries (capturing fish from floodplain wetlands). Other sources like riverine fisheries, production from miscellaneous sources constitute a small portion. The current average productivity in ponds is around 1,680 kg/ha/yr., while *beel* fisheries produce less than 500 kg/ha/yr. Therefore, Assam Government is making all-out efforts through different schemes to augment the fish production. The positive impact is evident from the fact that in the year 2020, Assam begged four top national level awards in the fisheries sector such as best state, best district, best Govt. organisation and best farmer from Govt. of India under 'Hilly and North Eastern' category. In last five years (from 2016-17 to 2020-21), the state has registered an increase of 28.4% in fish production and a spectacular 74.11% rise in seed production.

Climate Change Impact on Aquatic Food Production System of Assam

The climatic phenomena like rise in temperature, change in precipitation, flood, drought, etc. are affecting the aquatic food production system (both culture and capture fisheries) of Assam the most. Fish being the cold-blooded animal, its metabolic rate gets strongly affected by environmental conditions, especially the temperature. The changes in temperature have significant influence on the growth and reproductive biology of fish. The influence may be positive or negative depending on the circumstances. Extreme weather events like flood, drought can have serous negative impacts like crop loss due fish escape, mortality, etc. which have adverse economic and social impacts on the dependent communities like fish farmers and fishers. In order to minimise the negative impacts, a range of actions

are to be taken in form of adaptation measure to climate change.

The potential impacts of different drivers of Climate Change on Aquatic Food production System of Assam were analyzed critically. Drivers such as warming of water, lowering of dissolved oxygen, changes in other hydro-graphic variables, flood, drought, depletion of ground water, high intensity weather event, heavy rain, storm, etc. were considered for their impacts on fish, production system and stakeholder. Different colour legends were assigned to the impacts depending upon their positive and negative nature. The relevant adaptation options were also worked out and categorized as short-term, medium-term and long-term measures. The vulnerability of the aquatic food production system of Assam to climate change was mapped using the conceptual framework. The vulnerabilities of culture fishery and capture fishery to different climatic threats in the context of Assam were analyzed based on the likelihood of occurrence and the consequences. These helped in determining the impact level and vulnerability status of each threat.

Field Data Analysis & Results

The primary data were collected from field through questionnaire-based interviews, focus group discussions and PRA. The collected data were entered in MS Office excel software and reports were generated pertaining to relevant aspects of aquaculture and the impact of climate change on aquaculture. Knowledge-Attitude-Practice (KAP) survey was conducted in six districts, namely Barpeta, Nalbari, Nagaon, Darrang, Jorhat and Cachar comprising of total 60 fish farmers, 10 farmers randomly selected from each district. The broad areas covered in KAP survey were: (i) information on aquaculture, (ii) pond management, (iii) farmers' perceptions on climate change, (iv) impact of climate change on aquaculture, and (v) coping measures adopted by farmers.

Key Informant Interview (KII) covered 20 numbers of well-informed experts like fishery officials, researchers, academicians, etc. who had first-hand information and insight on the issues pertaining to climate change and its impact on fisheries. The semi-structured questionnaire was used and smooth conversation happened among the interviewer and informant with free flow of ideas and information on the topic. KII helped to get big picture idea of the situation.

Focus Group Discussions (FGDs) were held at 11 different locations on the topics like aqua farming, *beel* fishery and hatchery operation in six districts, namely Kamrup (M), Kamrup (R), Barpeta, Nalbari, Morigaon and Nagaon. For each discussion, a homogenous group of about 10-20 members involved in a particular type of activity took part in deliberation. The participants freely shared their viewpoints and perceptions on relevant issues irrespective of agreeing or

disagreeing to the issues. FGDs helped in capturing insights on (i) Perceptions on Climate Change and related hazards, (ii) Impact of Climate induced hazards on Aquatic food Production System, (iii) Coping / Adaptation Measures, (iv) Use of Weather Information, (v) Gender Issues, (vi) Nutrition sensitivity of Pond fishery & its vulnerability to climate change, and (vii) Indigenous Technical Knowledge - ITK used in Fisheries.

The Participatory Rural Appraisal (PRA) exercise was conducted at Bagibari village in Kamrup (M) district. Due to the time constraint, only one PRA exercise was conducted in the study. The sole purpose was only to demonstrate the usefulness of PRA as an effective process in strategizing the local level adaptation plan in Aquatic Food Production sector. To ensure active participation from the villagers, less writings and more of oral communication and tools of like pictures, symbols, physical objects and group memory were used. Information on changes and trends, the historical perspective on climate change and its impact on aquatic food production system of the locality were captured. The participants prepared different maps and charts about their localities and activities, namely transact map, land use map, resource flow map, mobility map, activity calendar and seasonality chart, problem diagram, matrix ranking, etc.

Evaluation of Fishery Technologies implemented by APART

Under APART, totally nine numbers of climate resilient technologies/ interventions are being demonstrated / implemented in 15 districts of Assam to facilitate adaptation to the impacts of climate change at the local level. These are: (1) Short Duration Fish Culture, (2) Overwintering of Seed (Stunted Yearling Production), (3) Paddy-cum-Fish Integrated Farming System, (4) Polyculture of Carps in Pond, (5) Multiple Stocking and Multiple Harvesting of Carp, (6) Carp polyculture with Mola and other SIS, (7) Polyculture of Carps and Fresh Water Prawn, (8) Cage culture in beels for fingerling & table fish, and (9) Production improvement in beels through stock enhancement. These technologies/ interventions were evaluated through the collection of field data and screening them through the lens of adaptation to climate change. Based on the type and nature of data collected, a common framework was developed to evaluate said technologies and it comprised several attributes such as (i) Key Features, (ii) Geographical Spread of Demonstration, (iii) Adaptation Hypothesis, (iv) Adaptation Benefits, (v) Production Results, (vi) Driving Forces, (vii) Restraining Forces, (viii) Actors Involved, (ix) Sustainability, (x) Replicability, (xi) Over-arching Impact (Economic, Social and Ecological), (xii) Institutional Mechanism and (xiii) Leanings.

ITKs in relation to Climate Resilient Practices

The rural population of Assam, especially the tribal communities have rich repertoire of traditional knowledge as they have a prolonged history of survival and coping strategies for the natural calamities like flood, drought, etc. for generations. Most of the ITKs were documented during FDGs. Upon analysis, it is found that ITKs are used in different areas like fish farming, disease management, hatchery operation, fishing, local environmental management practices, etc. A comprehensive list of such ITKs is prepared. There are examples where the local populations have developed and implemented the adaptation strategies through their indigenous knowledge systems, which enabled them to reduce the climate variability. In documentation process, old and experienced farmers /fishers were given preference to initiate the discussion on various ITKs being practised in culture and capture fisheries.

Gap Analysis in Climate Resilient Practices and Technology Adoption

The climate resilient practices and the technologies in aquatic food production system are relatively new to the stakeholders including farmers and fishers of Assam. The wider adoption of these technologies is difficult unless the constraints and bottlenecks are addressed properly. Unavailability of critical inputs in time, lack of customization of technology to local needs, economic barriers, social issues, lack of coordination between different government agencies or different levels of government, complexity of interdisciplinary approach, etc. are some of the commonly encountered problems. Often the information provided by the extension personnel appears to lack relevance to the need of the farmers. Therefore, in the study, an attempt is made to analyse the gaps in adoption of each technology being implemented under APART. It included the identification of gaps/problems, analyzing the nature of problems and finding the ways to reduce the gaps.

Integrating Fish Value Chain and Climate Resilience

In order to develop the sustainable aquatic food production system, it is necessary that entire fish value chain is made climate-proof through resilient technologies and policies. With climate change threatening fishery value chains at all stages, from production to processing and marketing, understanding the associated climate risks at each stage and having the value chain approach to climate resilience will be the key to risk management. Therefore, a conceptual framework for step-by-step mapping of entire Fish Value Chain from climate resilience perspective is worked out for the field use. Further, the value chain analyses with

adaptation options and suggested actions are illustrated for pond aquaculture and *beels* fisheries in Assam.

Climate-Smart Business Opportunities

'Seeing the opportunity in the crisis' is the philosophy for the climate-smart business activities. Climate change often brings many hidden opportunities for the individuals, agencies and entrepreneurs to innovate and invest befittingly in the challenging time. Investments in climate resilient action plans are rewarding when planned scientifically and executed judiciously in long-term prospective. In this study, an effort was made to critically examine the broad areas of aquatic food production system of Assam one by one through the lenses of business opportunity and identify the relevant climate-smart activities. Inspired by good risk management models, for climate-smart businesses, use of a risk management tool abbreviated as ADAPT (Analyze, Develop, Assess, Prioritize, and Tackle) is discussed.

Nutrition-Smart Aquatic Food System

The climate resilient technology should ideally address the nutrition sensitivity issues. There is no denying fact that fish is a food of excellent nutrition, providing high quality protein, omega-3 fatty acids and a wide variety of vitamins and minerals. The Small Indigenous Species (SIS) of fish are generally considered as nutrient-rich and offer big nutritional benefits, especially for women and children. The farmers, fishers and other stakeholders should be encouraged to adopt the practices that reduce the climate-induced risks and at the same time promote the sustainable production and availability of nutrition-rich foods. In the study, an attempt is made to illustrate relevant nutrition-sensitive interventions in the setting of Assam.

Gender Dimensions in Climate Change Vulnerability

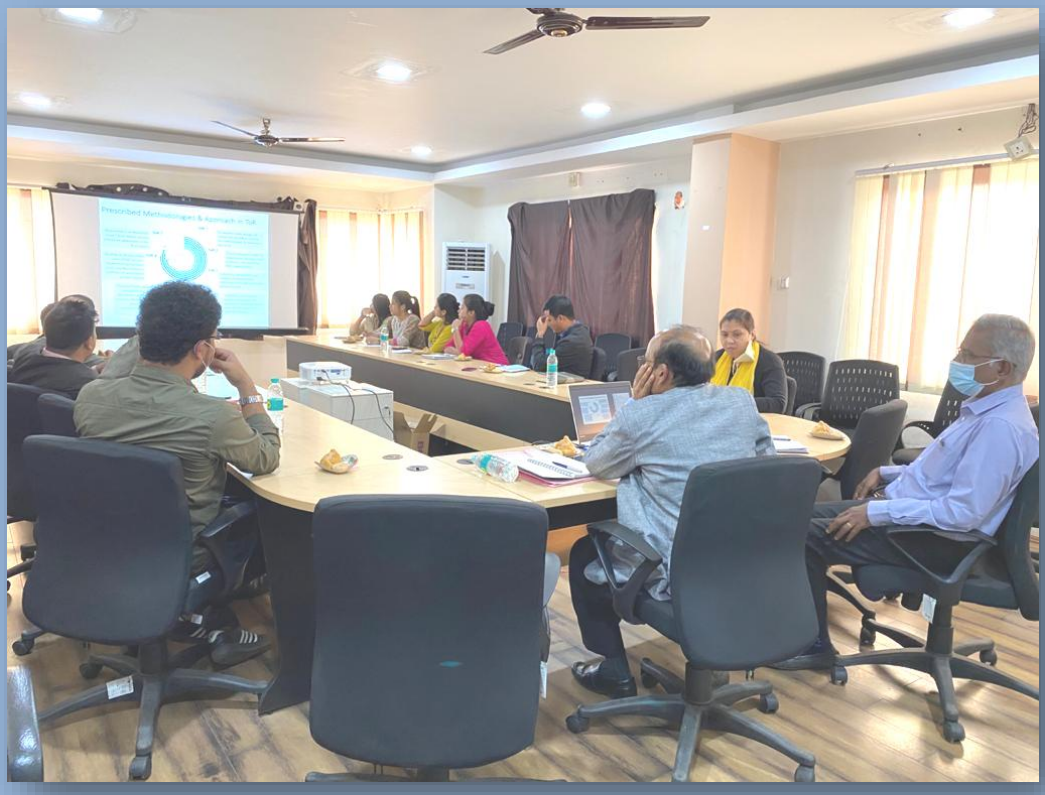
The impact of climate change on gender is not the same for men and women as they have different abilities to adapt and innovate. Women's vulnerability to climate change stems from a number of factors like social, economic and cultural. Women have less access than men to resources such as land, credit, inputs, decision-making structure, technology, training, extension service, etc. that would enhance their capacity to adapt to climate change. Under extreme situations, in the areas experiencing food or economic insecurity due to climate change, men are more likely to migrate to urban areas to find work, while women tend to remain at their native places in poorer conditions. To have a clear understanding of the issue at

field level, an attempt is made to develop an exhaustive gender analysis framework for fish value chain in the context of Assam.

Climate Resilient Strategies for Aquaculture & Fisheries

Upon critical analysis of prevailing situations, it is evident that the strategies on climate change adaptation in aquatic food production system need to be built around two pillars: an ecosystem approach to the production system andthe sustainable livelihood options . In this study, after careful considerations, an adaptation pathway comprising of six steps is proposed for sustaining aquatic food production system in Assam. Since the state is prone to frequent flooding, few suggested coping measures against flooding are narrated with pictorial illustrations for easy understanding. For the Department of Fisheries, Govt. of Assam, a framework is also suggested for mitigating the hazards caused by flood and drought.

1 Introduction



1. Introduction

1.1 Background

According to Global Climate Risk Index 2021, India has ranked seventh in the list of most-affected nations impacted by extreme weather events in 2019. In that year, monsoon continued for a month longer than normal in India. Flooding caused by heavy rain across 14 states including Assam led to the displacement of 1.8 million people with the economic damage estimated to the tune of US$ 10 billion (₹75,0000 million). In Assam alone, that year more than 5 million people got affected by flood in 30 districts with the estimated damage of over 0.16 million hectares of crop area which included the aquaculture ponds. Another report published in April, 2021 on 'Climate vulnerability assessment for adaptation planning in India using a common framework' reveals that 24 of India's 100 districts most vulnerable to climate change are in Assam. According to this study, Assam is amongst the eight most vulnerable states of India that requires prioritisation of adaptation intervention. The study was jointly conducted by IISc-Bengaluru, IIT-Guwahati and IIT-Mandi in 2019-2020 across 29 states of India. All these statistics speak volumes about the catastrophic impacts of climate induced changes on the life and livelihood of the people India in general and Assam in particular.

India being the one of the most thickly populated countries in the world (which supports 17.5% of global population only in 2.4% of the world's landmass), is extremely vulnerable to these climatic hazards. The November 2015 report of the World Bank says that climate change could effectively negate the economic progress of India, if not tackled effectively, pushing 45 million people into extreme poverty over next 15 years. The National Environment Policy of the Government of India also identifies environmental degradation a major causal factor in enhancing and spreading poverty, particularly among the rural poor. Hence promotion of sustainable agriculture including fishery and livestock will be the key to future development in food production system of the country. It goes without saying that the sustainable food production comes with climate resilient production strategy as an indispensable component.

When we talk about the food production system as a whole, it is an undeniable fact that, in future, more and more food will come from water as over two-third of the earth is covered with water. The terrestrial landmass is getting over exploited by various human activities including agriculture. Hence, the aquatic food production system will play a crucial role in meeting the global food need and more so for the populous countries like India. On the other hand, compared to land ecosystem, the aquatic ecosystem is more fragile to the climate induced changes. In fact, the aquatic resource is like a double-edged sword, if used judiciously will deliver the intended results and its reckless use will lead to grave consequences. In recent

decades, the fisheries sector, especially the aquaculture sub-sector, is performing very well and the trend is likely to continue for long. India currently holds the second position in total fish production, next to China. But unlike China, the increase in fish production in India will contribute more to the global fish need. This is due to the fact that India being a fish-surplus country, any increase in fish production, a considerable percentage of it will go to the global market. On the contrary, China being a fish-deficit country despite of huge production, any increase in fish production will mostly be used for domestic consumption and in real sense will contribute a little to the global fish need. Therefore, the development of aquaculture in India holds more relevance to the world.

In India, fishery is in different stages of development with varied resources and potential in its constituent states. Production from capture fishery has remained stable in the last few decades. But culture fishery has witnessed significant growth in the production. Therefore, the states having more aquaculture resources are showing faster growth than the states depending more on capture fisheries. Coming to Assam, it is a land-locked state with abundant water resources and shares about 2.4% of the country's geographical area with 2.6% population of the country. Being blessed with huge fishery resources and having the excellent tropical climate with average annual rainfall of over 1500 mm, it is undoubtedly one of the most potential states in India for the development of fisheries. Fish is also the staple food of the Assamese people. Despite of the favourable geo-social environment, the development of fisheries sector in Assam has not been impressive till recent past. In nutshell, Assam is a sleeping giant as far as the fishery resources and level of utilisation are concerned. One of the probable reasons for that is the vulnerability of the state to the climate induced hazards like flood, drought, etc. which are adversely impacting the fishery sector of the state. The geographical, geological and socio-economic characteristics of the state further aggravate the situation. But of late, the scenario in the state is gradually changing and it is changing for better. In last few years the sector has undergone considerable changes in structure and dynamics, and with an overall expansion in production, trade and consumption. In the year 2018, the state has launched World Bank assisted 'Assam Agribusiness and Rural Transformation Project (APART)' with fisheries as a sub-component in it. Through this project, WorldFish is extending the technical support to the state with its international experience and expertise. One of the focus areas of WorldFish in Assam is climate-proofing the fishery sector of the state by developing and promoting climate-resilient technologies. These will counter the negative impacts of climate change in fisheries, mainly the pond aquaculture and *Beel* fisheries. In short to medium term, the efforts will push the fish production of the state upward and will help in transforming Assam from a fish-deficit state to fish-surplus one. In long term, it will support the sustainable aquaculture and small-scale fisheries in the state.

When we analyse the climate change pattern in Assam, the climatic phenomena like rise in temperature, change in precipitation, flood, drought, etc. become prominent and these are affecting the aquaculture and fisheries of Assam the most. The rationale behind is the physiology of fish. Being the cold-blooded aquatic animal, metabolic rate of fish is strongly affected by environmental conditions, especially the temperature. The changes in temperature can have significant influence on the growth and reproductive biology of fish. The influence may be positive or negative depending on the circumstances. Extreme weather events like flood, drought can have serious negative impacts like crop loss due to fish escape, mortality, etc. which will have adverse economic and social impacts on the dependent communities like fish farmers and fishers. In order to minimise the negative impacts, a range of actions are taken / planned in the form of adaptation measures to climate change. The adaptation is the process of adjusting to change (both experienced and expected) with a long-term vision. The mitigation measure may be the other option which tends to lower or remove greenhouse gas emissions from atmosphere and thereby reducing the climate change naturally. Therefore, adaptation and mitigation are two sides of the same coin and must go hand in hand. But it may not be always possible or practical to identify the actions that are both adaptive and mitigating in nature.

It is pertinent to mention that, under the APART project some climate resilient interventions such as short duration fish farming, overwintering of seed, multiple stocking and multiple harvesting, hotel size fish production, paddy-fish integration, etc. have been introduced as adaption strategies to climate change in different districts of Assam. These interventions are at different stages of implementation. At this juncture, it is prudent to assess the field-level performance of these interventions to have course-corrections, if needed. Because, 'one-size-fits-all' approach should be avoided in state-level adaptation plans and the adaptation strategies should accommodate the local-level adjustments for better outcome. It will not be out of place to mention here that some novelty aspects like value-chain approach, gender-sensitive measures, nutrition-smart practices, etc. when included in adaptation strategy, they make it comprehensive. The value chain approach helps in analysing the climate change impact on entire series of activities starting from the fish production system till it reaches the consumer. In Assam, a large number of rural women depend on climate-sensitive resources for survival and their livelihoods. In some places, more women are engaged in farming due to extensive male migration (seasonal or permanent) and in these places the adaptation plans must be targeted for women. The nutrition-sensitive practices like paddy-fish farming, integrated fish-vegetable farming, inclusion of self-recruiting small indigenous fish species in polyculture system, etc. should also find place in adaptation strategies. The relevance lies in increasing the availability,

accessibility and consumption of nutrient-rich fish by producers and poor consumers, with particular emphasis on women and children.

1.2 Objectives of the Study

Assam Agribusiness and Rural Transformation Project (APART) is a World Bank assisted project being implemented in Assam state of India by Assam Rural Infrastructure and Agricultural Services (ARIAS) Society. WorldFish is providing technical support in the implementation of the project's fisheries sub-component. Developing and promoting the climate-resilient technologies in support of sustainable aquaculture and small-scale fisheries is one of the broad objectives of the fisheries sub-component. The proposed study would support resilience of fisheries and aquaculture production systems in order to increase fish production and minimize/reduce risks associated with climate change, in the targeted districts.

The specific objectives of the study are:

- Mapping the existing climate resilient technologies being practiced by fish farmers in pond/tank and beel fisheries in the state of Assam with reference to the project development objective (PDO) of APART
- Mapping of the existing fish farming technologies being implemented with special reference to the Indigenous Technical Knowledge (ITK), its applicability and adoption
- Addressing the gaps in the adoption of technology of intensive farming practices, their mitigation and technology upgradation strategy
- Scoping the application/adoption of climate resilient fish farming, processing, trading/ marketing practices by fish value chain players in the state of Assam

1.3 Methodology

Based on the Terms of References (ToR) of the study, following steps were followed in sequential order to accomplish the study in a cohesive manner. Both qualitative and quantitative research methodologies were used for the study.

Table:1.1 Sequential Steps involved in the Study

Steps	Description	Process involved
Step 1	Desk Research	Critical review of published reports and statistics

Step 2	Questionnaire Development for Survey	Knowledge-Attitudes-Practices (KAP) Survey, Key Informant Interview (KII), Focus Group Discussion (FGD), Participatory Rural Appraisal (PRA), Case Study
Step 3	Conducting Survey	Field survey to collect primary data and to sense the ground reality
Step 4	Collation of Information	Collation of data and information gathered through desk research and field survey, use of information for decision-making and drawing strategies
Step 5	Formulation of Climate Resilient Technologies & Strategies	With the help of data and his professional judgement, the consultant spelt out suitable technologies and formulated appropriate strategies
Step 6	Submission of Draft Report	The compiled information, results, strategy plan and key findings on Climate Resilient Technologies & Strategies submitted as Draft Report for comments and feedbacks
Step 7	Submission of Final Report	Based on the comments and feedbacks received, the draft report was modified and submitted to WorldFish as final report

1.3.1 Desk Research

The desk research started with a critical review of published reports and statistics on the Climate of Assam, Observed Changes and Projections. The literatures pertaining to potential impacts of climate change on culture and capture fisheries of Assam were reviewed in detail. Following documents were referred extensively for information, interpretations and inferences.

- State Level Climate Change Trends in India (1951-2010)
- Revised Assam State Action Plan for Climate Change with Monitoring and Evaluation Framework-2019
- Assam Agribusiness and Rural Transformation Project (APART) - Work Plan, Annual Reports & other Publications
- WorldFish Research Programs- Sustainable Aquaculture, Resilient small-scale Fisheries, Climate Change impacts on fisheries and aquaculture
- CGIAR Research Programs on Climate Change, Agriculture and Food Security
- Impacts of climate change on fisheries and aquaculture- FAO Technical Paper No. 627
- Plans and Programmes of State Fisheries Department, Govt. of Assam
- Pradhan Mantri Matsys Sampada Yojana (PMMSY), 2020
- Blue Revolution Schemes (Activities & Achievements), Govt. of India

- National Fisheries Policy (Draft)

Whilst many information could be obtained from the desk review and secondary sources of data (reports, studies, policy and plans), in order to check the ground reality and to collect first-hand information, contact was established with the fish farmers, fishermen, scientists, experts, extension functionaries and other stakeholders. This was achieved through questionnaire-based survey, focus group discussion, Participatory Rural Appraisal (PRA) and workshop.

1.3.2 Knowledge-Attitude-Practice (KAP) Survey

Knowledge-Attitude-Practice (KAP) surveys were conducted amongst the 60 numbers of fish farmers in six districts (in-person survey-30 Nos. and telephonic survey-30 Nos.) using the pretested questionnaires. The primary objective of this survey was to evaluate the knowledge, attitude and prevailing practices of the stakeholders towards climate change, impact of climate change on aquaculture, prevailing coping practices, etc. The respondents for survey were selected randomly.

1.3.3 Key Informant Interview (KII)

Key Informant Interview (KII) covered 20 numbers of well-informed stakeholders like fishery officials, researchers, academicians, experts, etc. who had first-hand information and insight on the issues pertaining to climate change and its impact on fisheries. The semi-structured questionnaire was used and smooth conversation happened among the interviewer and informant with free flow of ideas and information on the topic. KII helped to get big picture idea of the situation.

1.3.4 Focus Group Discussion (FGD)

Focus Group Discussions (FGDs) were conducted in three areas of activity, such as culture fishery, capture fishery and seed production. Activity-specific FGDs were conducted for in-depth discussion and to capture the stakeholders' views. Total 12 numbers of FGDs were conducted and on an average 10-15 participants took part in each FGD. The participants freely shared their viewpoints and perceptions on relevant issues irrespective of agreeing or disagreeing to the issues. The discussion involved dual moderators; one moderator ensured the smooth progress of the session, while another ensured the inclusion of all relevant issues. FGDs generated lots of qualitative primary data on the pertinent topics and some nuances.

1.3.5 Participatory Rural Appraisal (PRA)

In the present study, one PRA exercise was done to demonstrate the use of PRA as an effective process in strategizing the local level adaptation plan in Aquatic Food

Production System. PRA was structured to quickly acquire information through interaction and joint exercise on the rural life, problems and solutions with focus on climate change impacts on fisheries and aquaculture. It used wide range of tools and techniques (detailed below) for observations, group discussion, drawing maps, charts, diagrams, etc. It provided suitable platform for shared learning between the local people and WorldFish functionaries.

Table 1.2 Details of attributes & tools/methods used in PRA

Attributes	Tools / methods used	Remarks
Identification of Village	Discussion with APART officials	One representative village was selected
Understanding geographic layouts, micro-farming situation and preparation of transect map	Transect walk, Village map	Mapping with sketch pen on paper, modelling on the floor with colour powder
Historical background of village, changes and trends	Time line	Participatory group discussion with elderly people
Historical perspective on climate change and its impact on aquatic food production system	Group discussion, Voices from the community	Participatory group discussion with elderly people
Preparation of village land use map, mobility map, Seasonality and farm activity calendar	Mapping and modelling	Mapping with sketch pen on paper, modelling on the floor, use of paper cut-out circles
Preferences of fish species, practices in culture fisheries	Matrix scoring and ranking	By assigning scores against attributes
Resource flow analysis of inputs and outputs	Resource flow mapping	Mapping with sketch pen on paper
Problem identification in culture and capture fisheries	Matrix Ranking	Ranking by participants
Problem cause relationship	Problem cause diagram	Diagram by participants
Climate-resilient strategies	Participatory group discussion	Participants put forth the strategies, core team facilitate their involvement

1.4 Study Area and Sample Size

The field survey was conducted in-person just to sense the ground reality and to collect some quantitative primary data. The service of the field level enumerators was utilized for the purpose. The survey covered few representative districts of the

state in consultation with Fishery Directorate of Assam & APART-WorldFish Project. Due to the COVID-19 pandemic and imposition of Model Code of Conduct by Election Commission of India in Assam for Assam Legislative Assembly Election-2021, the sample size under each respondent category was kept relatively small. There were fair number of women respondents. The filled-up questionnaires were checked before analysis for any missing data or error.

Table 1.3 District-wise distribution of respondents

Survey Name	Respondent Category	Sample Size	District Spread								
			Kamrup(M)	Kamrup(R)	Barpeta	Nalbari	Morigaon	Nagaon	Darrang	Jorhat	Cachar
KAP Survey	Aqua farmers	**60**			✓10	✓10		✓10	✓10	✓10	✓10
KII (20)	CoF, Raha	**7**						✓7			
	ICAR-CIFRI	**9**	✓9								
	ARIAS Society/DoF	**2**	✓2								
	NFDB	**2**	✓2								
FGD (11)	Aqua Farmer Group	**6**	✓1		✓2	✓1		✓2			
	Hatchery Operator Group	**2**				✓1		✓1			
	Beel Fisher Group	**3**		✓1	✓1		✓1				
PRA	Beneficiaries of APART	**1**	✓1								
Case Study (4)	Paddy-Fish Integration	**1**				✓1					
	Short duration Fish Farming	**1**					✓1				
	Polyculture with Mola	**1**				✓1					
	Polyculture with Prawn	**1**				✓1					
	Total	**97**	15	1	13	15	2	21	10	10	10

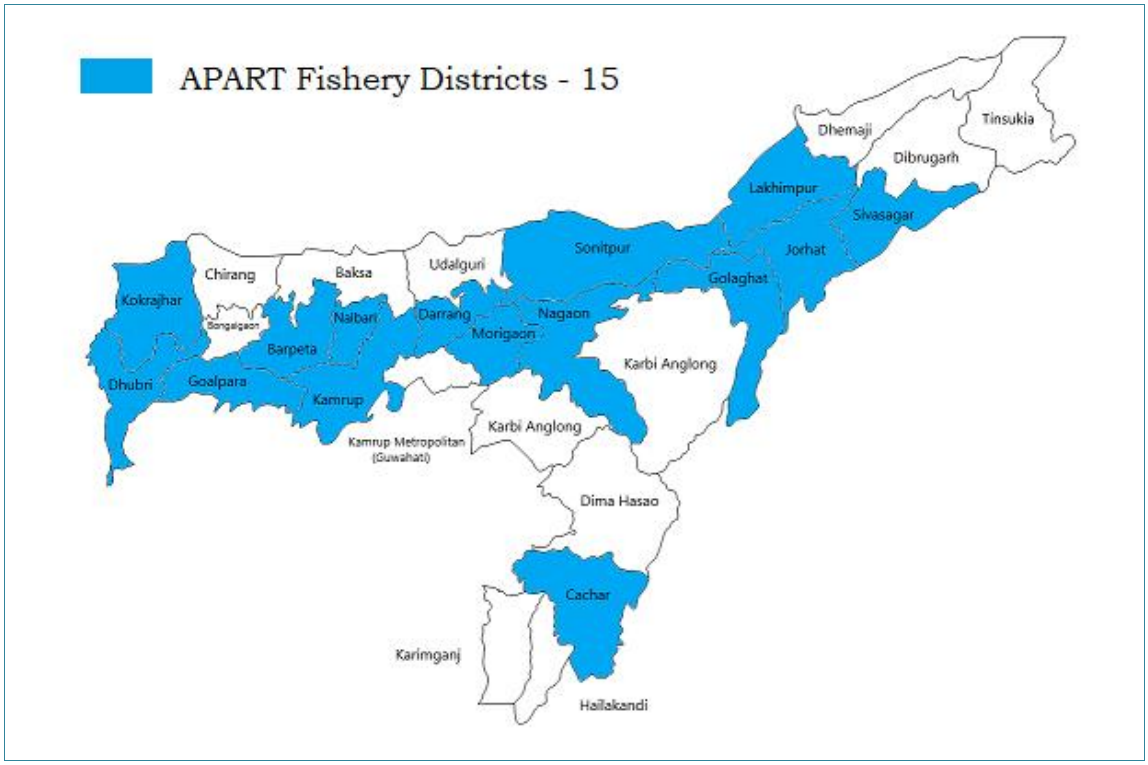


Figure 1.1 Map of Assam showing APART Fishery Districts

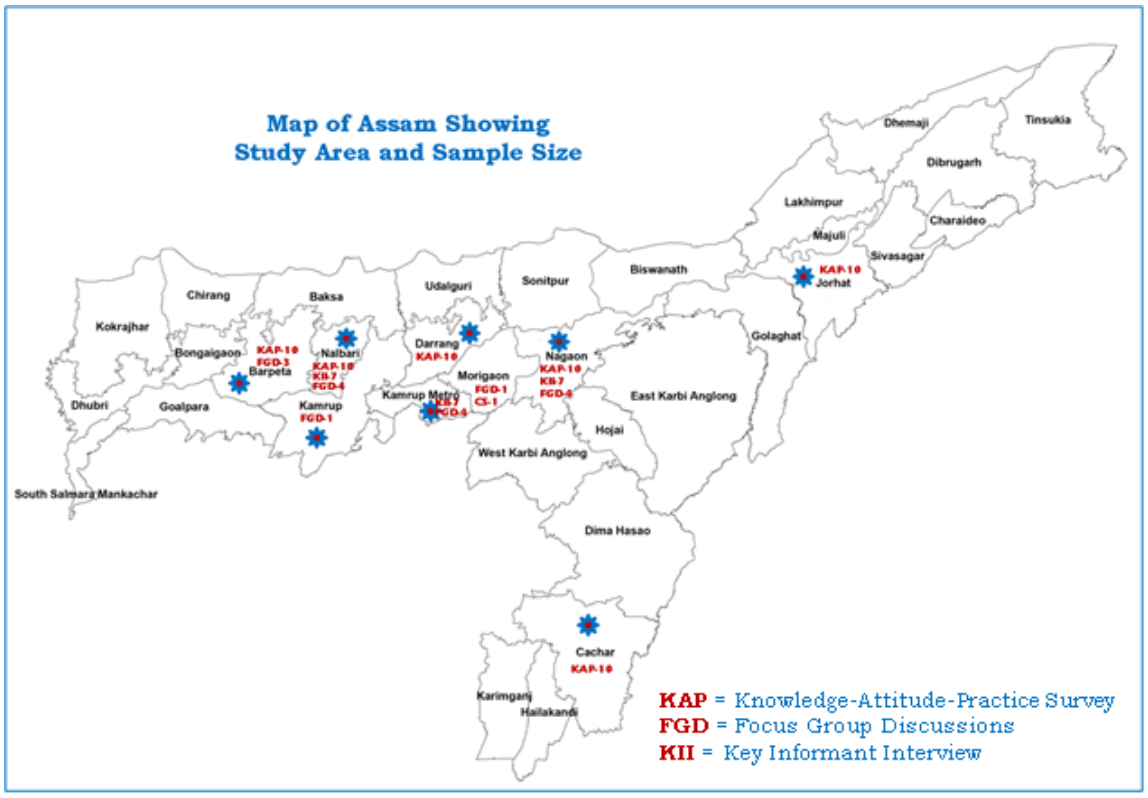


Figure 1.2 Map of Assam showing study area and sample size

1.5 Survey Questionnaires

The in-depth desk research gave an insight on the areas to be focused in developing questionnaires. To capture a wider diversity of viewpoints on the subject, resource specific and stakeholder-wise questionnaires were developed. The questionnaire started with more general questions and gradually moved to greater specificity towards the end. Clear and easy-to-understand questions were asked. All these questionnaires were multi-layered and covered only the questions pertinent to specific stakeholders. The questionnaires included both open-ended and close-ended questions. The questions were framed in such a way that it would not lead a respondent to any preferred response. The broad areas covered in the questionnaires are illustrated below.

Table 1.4 Broad areas covered in questionnaire-based survey

Questionnaire Name	Respondent Group	Broad Areas Covered	Enclosure of Sample
Knowledge-Attitude-Practice (KAP) Survey	Aqua Farmers	▪ Information on aquaculture ▪ Pond management ▪ Farmers' perceptions on Climate change ▪ Impact of climate change on aquaculture ▪ Coping measures adopted by farmers ▪ ITKs in aquaculture	Annexure I
Key Informant Interview (KII)	Researchers Academicians Experts Officials	▪ Perceptions on Climate Change ▪ Impact of Climate Change on Seed Production, Culture & Capture Fishery ▪ Coping Measures for Seed Production, Culture & Capture Fishery ▪ Adaptation Strategy for Culture & Capture Fishery ▪ Climate Change Impact on Fish Value Chain ▪ Climate Smart Investment Opportunity in Fisheries	Annexure II
Focus Group Discussion (FGD)	Aqua Farmers	▪ Perceptions on Climate Change and related hazards ▪ Impact of Climate induced hazards on Aquatic food Production System ▪ Coping / Adaptation Measures ▪ Use of Weather Information ▪ Gender Issues	Annexure III

		▪ Nutrition sensitivity of Pond fishery & its vulnerability to climate change ▪ Indigenous Technical Knowledge (ITK) used in Fisheries	
	Beel Fishermen	▪ Perceptions on Climate Change and related hazards ▪ Impact of Climate induced hazards on Aquatic food Production System ▪ Coping / Adaptation Measures ▪ Use of Weather Information ▪ Gender Issues ▪ Nutrition sensitivity of *Beel* fishery & its vulnerability to climate change ▪ Indigenous Technical Knowledge (ITK) used in Fisheries	Annexure IV
	Hatchery Operators	▪ Information about Hatchery Operation ▪ Perceptions on Climate Change and related hazards ▪ Impact of climate variation on Fish Breeding & Seed Rearing ▪ Coping / Adaptation Measures ▪ Use of Weather Information ▪ Indigenous Technical Knowledge (ITK) used in Fish Breeding and seed rearing	Annexure V
Participatory Rural Appraisal (PRA)	Project Beneficiaries /Villagers	▪ Background of village, changes and trends ▪ Historical perspective on climate change and its impact on aquatic food production system ▪ Preparation of village map, land use map, mobility map, Seasonality in the incidences of fish diseases, farm activity calendar, etc. ▪ Problem identification in culture and capture fisheries ▪ Problem cause relationship ▪ Climate-resilient strategies ▪ Documentation of ITK	

1.6 Collation of information

All data and information gathered through desk research, surveys, focus group discussion and PRA were collated for meaningful interpretation and were effectively used in decision-making and drawing strategies. Standard statistical tools and

other tools like seasonal calendar, enterprise ranking, Problem diagram, matrix ranking, etc. were used for meaningful inference. The Consultant used his professional judgement to make appropriate assumptions and spelt these out clearly in the report in the absence of adequate data.

1.7 Report Submission

The outcome of the study including the analysis, results, action plan and key findings were compiled in the form of the draft report and submitted to WorldFish for comments. Final report will be submitted after incorporating all suggestion and feedback.

2

Context

Climate Change Trends & Fisheries in Assam

2. Context - Climate Change Trends & Fisheries in Assam

2.1 Climate Change trends and associated risks in Assam

2.1.1 Geophysical Features of Assam

Assam, located between 21.570-29.300 N latitude and 89.460-97.300 E longitude, is the largest north eastern state of India in population and second in terms of area. Its physical landscape covers an extensive area of 78,438 sq. km and occupies about 30 per cent of the North Eastern Region of India. It is bordered by Bhutan and Arunachal Pradesh in the north; Nagaland and Manipur in the east; Meghalaya, Tripura, Mizoram and Bangladesh in the south; and West Bengal in the west. As evident, the state shares international boundaries with Bangladesh and Bhutan. A narrow strip of land known as Siliguri corridor connects the state to the rest of India and therefore aptly described as the gateway to the North East India. Assam shares about 2.4% of the country's total geographical area and provides shelter to 2.6% population of the country. The Brahmaputra and Barak rivers along with their tributaries and numerous flood-plain wetlands give a distinctive hydro-geomorphic feature to the region. This greatly influences the life and livelihood of the people along with the diversity. The region receives more rainfall than most parts of India and looks green all year round. The state is well-known for its plentiful forest resources and is a home to six National Parks and nineteen Wildlife sanctuaries, the highest concentration in India. Kaziranga and Manas National Parks with high species diversity and visibility are registered as UNESCO world heritage sites. The floral diversity of the State consists of tropical rainforests, deciduous forests, riverine grasslands, bamboo orchards and numerous wetland ecosystems. The State is severely affected by devastating floods every year, which not only washes away valuable life and crops, but also lead to river bank erosion and drainage congestion, destroying the economy. Assam is known for its tea, petroleum resources, muga silk and bio-diversity including one-horned rhinoceros. Assam is administratively divided into 33 districts (30 districts are in Brahmaputra valley and 3 districts are in Barak valley) with 80 sub-divisions, 219 Development Blocks and 2202 Gram Panchayats.

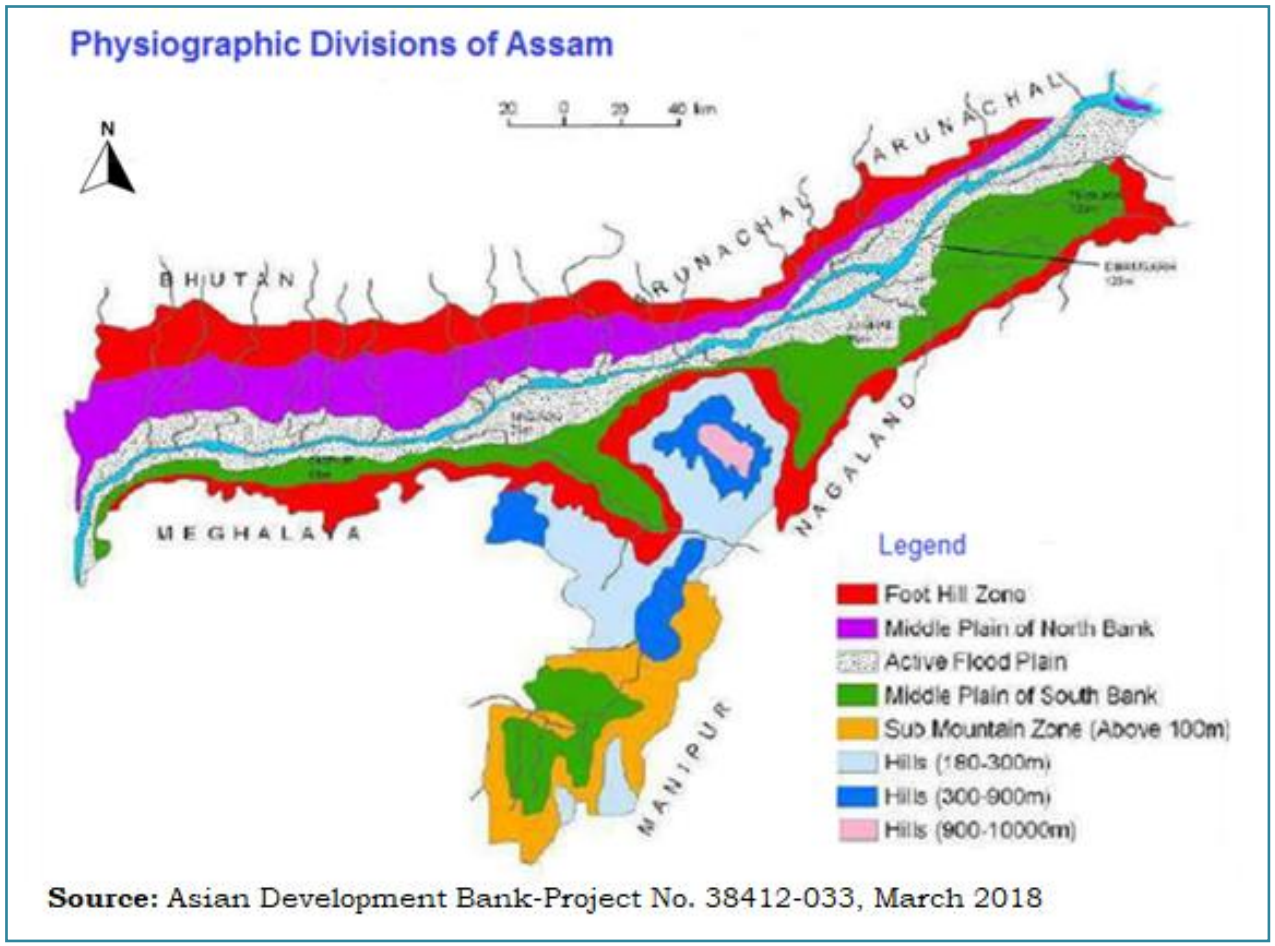


Figure 2.1 Physiographic Divisions of Assam

2.1.2 Climate of Assam

Assam has the moderate climate which falls under "tropical monsoon rainfall" type, with high levels of humidity and heavy rainfall. The climatic variations are observed regionally. While the plains of Assam have tropical climate with high humidity, the hills have sub-alpine type of climate. In the plains of Assam, the maximum temperature does not go beyond 32^{0}C and in winter the plains of Assam have a minimum temperature of about 8^{0}C. There are three distinct seasons in Assam, i.e., summer, rainy, and winter. The summer season starts from the month of March and extends till the end of June. The season is characterized by extreme humidity and frequent showers. The average temperature during this time of the year is between 35 and 38C. The rainy season begins in June and often goes on till September. The average annual rainfall in the state is around 175 cm in the west and around 300 cm in the east. The winter season prevails from the month of October to the end of February. There are two other short seasons namely spring and autumn representing the transition between cold and summer seasons and that between rainy and cold seasons respectively.

2.1.3 Observed Changes in Climate & Climatic Events of Assam

India Meteorological Department, Ministry of Earth Sciences, Government of India has undertaken the long-term assessment of the climate change for a 60-year period, during 1951-2010 for each state of the country including Assam. It contains assessment of the annual, seasonal and monthly climate change trends in maximum, minimum and average temperatures, diurnal temperature range and precipitation. In Assam, the analysis is based on data collected from 6 Stations for temperature and 12 Stations for rainfall. The analysis indicates that the mean temperature in the State has increased by +0.01 -C/year. There is also an increase in seasonal temperatures across seasons with pronounced warming in post monsoon and winter temperatures. The annual rainfall has also decreased by -2.96 mm/year during the same period.

Table 2.1 Season-wise Trends of Change in Temperature and Rainfall in Assam over a 60-year period (1951-2010)

Seasons	Mean Max Temp (°C)	Mean Min Temp (°C)	Mean Temp (°C)	Mean Diurnal Temp Range (°C)	Rainfall (mm)
Annual	+ 0.02*	+ 0.01*	+ 0.01*	No trend	2.96
Winter	+ 0.01	+ 0.02*	+ 0.01*	No trend	+ 0.08
Summer	No trend	+ 0.01*	No trend	- 0.01*	- 0.56
Monsoon	+ 0.01*	+ 0.01*	+ 0.01*	No trend	2.19
Post Monsoon	+ 0.02*	+ 0.02*	+ 0.02*	No trend	0.75

Notes: Increasing (+) and decreasing (-) trends; significant at 95% level of significance are shown in bold and marked with * sign.

Table 2.2 Month-wise Trends of Change in Temperature and Rainfall in Assam over a 60-year period (1951-2010)

Months	Mean Max Temp (°C)	Mean Min Temp (°C)	Mean Temp (°C)	Mean Diurnal Temp Range (°C)	Rainfall (mm)
January	+ 0.01	**+ 0.01***	**+ 0.01***	- 0.01	- 0.09
February	+ 0.01	**+ 0.02***	+ 0.01	- 0.01	+ 0.16
March	No trend	**+ 0.02***	+ 0.01	**- 0.02***	+ 0.14
April	**- 0.02***	+ 0.01	- 0.01	**- 0.03***	+ 0.75
May	**+ 0.02***	**+ 0.01***	**+ 0.01***	+ 0.01	**- 1.46***
June	**+ 0.02***	**+ 0.01***	**+ 0.02***	+ 0.01	**- 1.59***
July	+ 0.01	**+ 0.01***	**+ 0.01***	No trend	- 0.55
August	**+ 0.02***	**+ 0.01***	**+ 0.01***	No trend	- 0.62
September	No trend	**+ 0.01***	+ 0.01	No trend	- 0.14

October	+ 0.02*	+ 0.01*	+ 0.02*	+ 0.01	- 0.47
November	+ 0.02*	+ 0.02*	+ 0.02*	No trend	- 0.11
December	+ 0.02*	+ 0.02*	+ 0.02*	No trend	- 0.04

Source: Rathore *et al.*, 2013

2.1.3.1 Rainfall Pattern of Assam

The North-Eastern region of India is one of the highest rainfall receiving regions on the Earth. Assam valley being located between the Himalayas to the north and other ranges to the south and east, experiences the rain-shadow effect. On the southern slopes of the Khasi-Jaintia hills, annual rainfall is over 1000 cm, while on the north in the Brahmaputra valley it decreases to less than 200 cm (Rao, 1981). The monsoon rainfall increases from south to north and also from west to east over subtropical Assam. Pre-monsoon rains are caused mainly by the depressions moving from the west and by local convectional storms. Rainfall is quite low in the winter and post-monsoon seasons (Barthakur, 2004). Jhajharia et al. (2012) published a report in which the monthly data of rainfall and rainy days of twenty-four stations of Assam were obtained from India Meteorological Department (IMD), Pune and Tocklai Tea Research Station, Jorhat. The figure and table show the spatial distribution of all the twenty-four stations in the four zones (lower Assam, middle Assam, upper Assam and southern Assam).

Trends in total rainfall and rainy days are identified using the Mann-Kendall non-parametric method, which are also confirmed by the parametric approach. On monthly time scale, at least sixteen sites of Assam witnessed decreasing trends in total rainfall in June, July and December, out of which a few trends were found to be statistically significant at 5% significance level. On the other hand, seventeen and twenty-two sites witnessed increasing trends in total rainfall in September and February, but only three trends were found to be statistically significant in February. Similarly on annual and seasonal time scales, both increases and decreases in rainfall were witnessed, however most time series were statistically non-significant at 5% significance level. In case of 24 h maximum rainfall, all but two sites witnessed no trend over Assam. Rangia and Haflong witnessed significant decreasing trends in 24 h maximum rainfall. At least twenty-one sites witnessed decreasing trends in rainy days during the months of June, July and November to January, but the trends were found to be statistically significant for seven or more sites in Assam in these months. On seasonal time scales, the majority of sites in Assam witnessed decreasing trends in rainy days, but the trends were statistically significant at about half of the sites in Assam mainly in the monsoon and post-monsoon seasons. Since the observed changes in rainfall and rainy days in Assam are not encouraging as the trends witnessed for most of the sites are statistically non-significant.

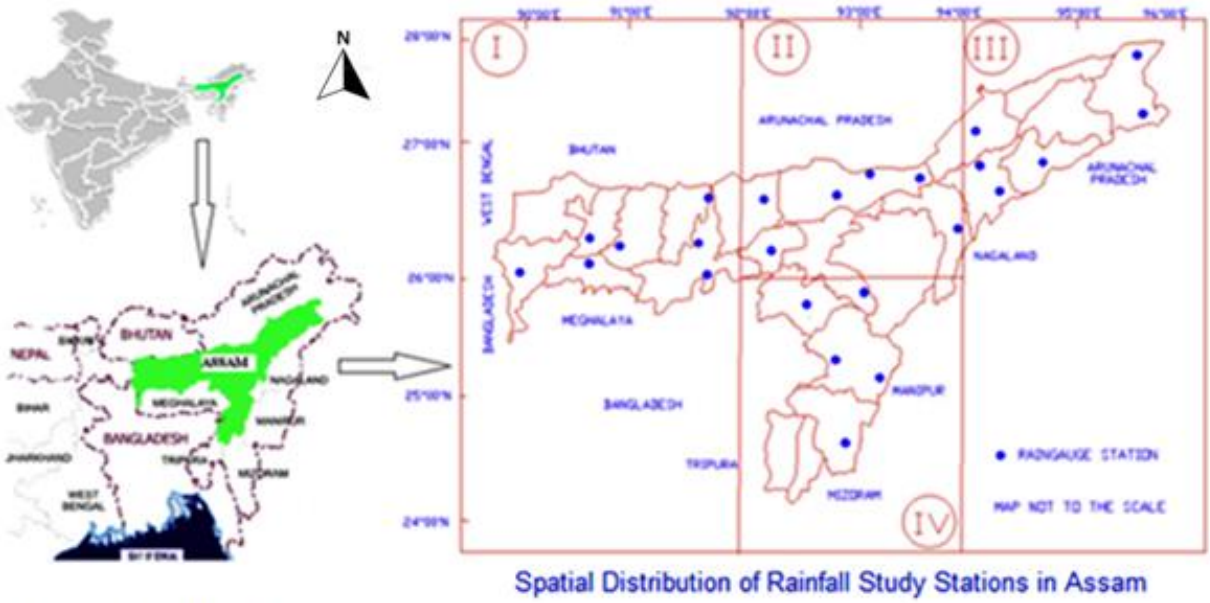


Figure 2.2 Spatial distribution of all the twenty-four stations considered for Rainfall study in Assam

Table 2.3 List of twenty-four stations considered by Jhajharia *et al.* to investigate the trends in rainfall in Assam

Sl. No.	Station	District	Lat. (N)	Long. (E)	Period
Region I (Lat. 26⁰ - 28⁰ N and Long. 89⁰ - 92⁰ E) – Lower Assam					
1	Dhubri	Dhubri	26⁰ 01’	89⁰ 59’	1951–2003
2	Goalpara	Goalpara	26⁰ 11’	90⁰ 38’	1954–2003
3	Goibargaon	Nalbari	26⁰	91⁰	1976–2003
4	Guwahati	Kamrup	26⁰ 11’	91⁰ 45’	1951–2003
5	Rangia	Kamrup	26⁰ 27’	91⁰ 37’	1957–2003
6	Mathungari	Barpeta	26⁰	90⁰	1977–2003
7	Panbari	Bongaigaon	26⁰	90⁰	1976–2003
Region II (Lat. 26⁰–28⁰ N and Long. 92⁰–94⁰ E) - Middle Assam					
8	Dharmatal	Marigaon	26⁰	92⁰	1976–2003
9	Gohpur	Sonitpur	26⁰ 53’	93⁰ 38’	1958–1999
10	Golaghat	Golaghat	26⁰ 31’	93⁰ 59’	1954–2003
11	Majbat	Darrang	26⁰ 45’	92⁰ 21’	1954–2001
12	Tezpur	Sonitpur	26⁰ 37’	92⁰ 47’	1951–2003

13	Thakurbari	Sonitpur	26⁰ 48’	92⁰ 42’	1973–2000
Region III (Lat. 26⁰–28⁰ N and Long. 94⁰–96⁰ E) - Upper Assam					
14	Digboi	Tinsukia	27⁰ 24’	95⁰ 37’	1954–2003
15	Lilabari	Lakhimpur	27⁰ 14’	94⁰ 07’	1954–2003
16	Margherita	Tinsukia	27⁰ 18’	95⁰ 40’	1979–2000
17	Neamatighat	Jorhat	26⁰	94⁰	1976–2003
18	Tocklai	Jorhat	26⁰ 47’	94⁰ 12’	1965–2000
19	Sibsagar	Sibsagar	26⁰ 59’	94⁰ 38’	1951–2003
Region IV (Lat. 24⁰–26⁰ N and Long. 92⁰–94⁰ E) - Southern Assam					
20	Halflong	N.Cachar Hills	25⁰ 10’	93⁰ 01’	1951–2001
21	Kheronighat	Karbi Anglong	25⁰	92⁰	1976–2003
22	Lumding	Nowgaon	25⁰ 45’	93⁰ 11’	1951–2003
23	Silchar	Cachar	24⁰ 49’	92⁰ 48’	1951–2003
24	Silcoorie	Cachar	24⁰ 50’	92⁰ 48’	1965–2000

Table 2.4 Trends of Number of Rainy Days and 24 Hr Maximum Rainfall across Assam

S. N.	Station	District	Rain Days					24 hr max rainfall
			Annual	Winter	Pre-monsoon	Monsoon	Post-monsoon	
West Assam								
1	Dhubri	Dhubri	+0.15	+1.04	+0.10	-0.63	+0.35	-1.32
2	Goalpara	Goalpara	+0.03	+0.16	-0.93	-0.96	-0.19	-1.62
3	Goibargaon	Nalbari	+0.83	-1.03	+0.75	+0.32	**-1.97**	1.19
4	Guwahati	Kamrup	-0.42	+0.06	-0.75	-1.67	-1.67	+0.17
5	Rangia	Kamrup	-0.61	-1.53	+0.19	-0.96	-1.02	**-2.09**
6	Mathungari	Barpeta	**-2.17**	**-2.53**	-0.52	**-2.22**	**-2.25**	-0.75
7	Panbari	Bangaigaon	+0.40	-0.66	+0.24	-0.24	-1.45	+0.01
North Central Assam								
8	Dahrmatala	Marigaon	+0.04	-0.29	-0.92	+0.72	-1.58	+0.50
9	Gohpur	Sanitpur	+0.34	-0.12	-0.62	-0.43	+0.29	+0.55
10	Golaghat	Golaghat	-1.61	-1.23	-1.30	-1.40	**-2.00**	-1.23
11	Majbat	Darrang	**-2.80**	-1.16	-1.52	**-2.82**	-1.69	-0.49
12	Tezpur	Sonitpur	-0.14	-0.34	-0.55	-0.43	**-2.65**	+0.85

Eastern Assam								
13	Digboi	Tinsukia	-1.09	-1.20	-0.34	**-2.15**	-1.68	-0.74
14	Lilabari	Lakhimpur	-0.06	-0.96	+0.13	+0.54	-2.12	+0.11
15	Nimatighat	Jorhat	-1.15	+0.43	-0.55	-2.02	-2.53	-1.07
16	Sivasagar	Sivsagar	-1.37	+0.11	-0.20	**-2.75**	-1.44	-1.07
Southern Assam								
17	Halflong	N Cachar Hills	-1.80	+0.77	-1.92	**-2.28**	-0.38	**-2.03**
18	Kheronighat	Karbi Anglong	+0.02	+1.43	-0.04	-0.68	-1.09	+0.55
19	Lumding	Nowgaon	-0.58	+0.72	+0.39	**-2.39**	-0.75	-1.75
20	Silchar	Cachar	-1.12	+0.28	-0.75	**-2.07**	+0.69	-1.57

Note: Bold numbers are statistically significant at 5% level of significance.
(Source: Jhajharia et al. 2012)

2.1.3.2 Flood Hazards in Assam

Assam with its vast network of rivers is prone to natural disasters like flood and erosion. The Brahmaputra and Barak River with more than 50 numbers of tributaries, causes the flood devastation in the monsoon period each year. The flood and erosion problem of Assam is singularly different from other states so far as extent and duration of flooding and magnitude of erosion is concerned. It is probably the most acute and unique in the country. The flood problem of the state is further aggravated due to flash floods by the rivers flowing down from states of Arunachal Pradesh, Meghalaya and neighbouring country of Bhutan. The flood prone area of the state as assessed by the Rashtriya Barh Ayog (RBA) is 31.05 Lakh hectares against the total area of state 78.523 Lakh hectares (39.58 % of the total land area of Assam as against the national average of 10.2 %). It signifies that the flood prone area of Assam is about four times the national mark. During post-independence period, Assam faced major floods in 1954, 1962, 1972, 1977, 1984, 1988, 1998, 2002, 2004 and 2012. Almost every year three to four waves of flood ravage the flood prone areas of Assam.

National Remote Sensing Centre (NRSC), ISRO has developed the flood hazard map of using satellite images of Assam acquired during floods of last 18 years (1998-2015). The most frequently inundated districts and villages were categorised into five hazard classes as Very High, High, Moderate, Low and Very Low, based on the frequency of inundation. Very Low category indicates the areas, which are inundated once or twice during the 10-year period. Similarly, Low indicates three

to four times, Moderate indicates five to six times, High indicates seven to eight times and Very High indicates nine to ten times (almost every year).

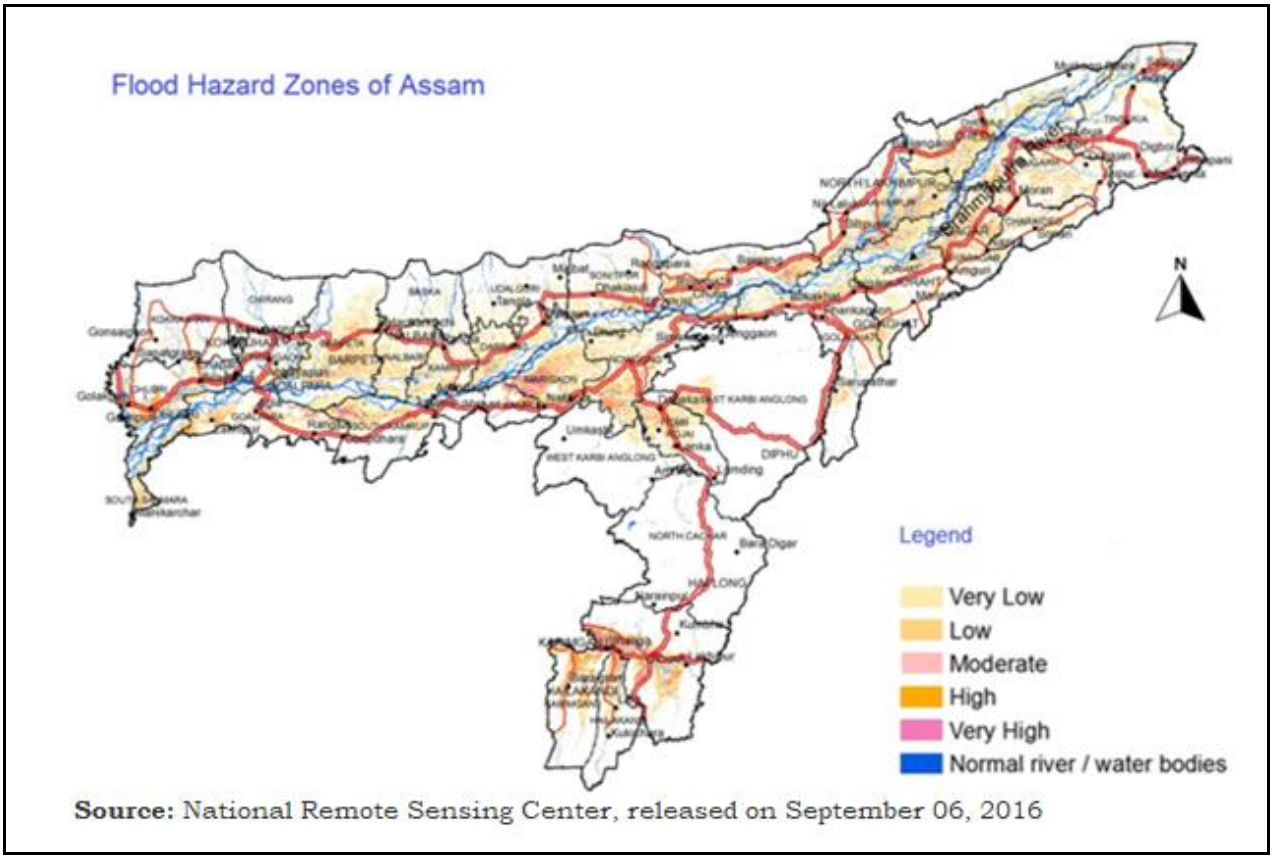


Figure 2.3 Updated Flood Hazard Map of Assam-1998-2015

Box 2.1 Voice from the Ground on Flood

Mr. Debeswar Deka
Age: 65 yrs., Retd. Head Master, Paka mouza Adarsha High School, Golibandha, Barpeta

Voice from the Ground on Flood

Hello! I am Debeswar Deka, 65 years old. I am born and brought up in the Golibandha village, a food-affected area in Barpeta district of Assam. Five years back I have retired from service as Head Master of Paka mouza Adarsha High School and have wife, a son and a daughter in my family. I have 7 *bigha* (0.98 ha.) of agricultural land and 1 ½ *bigha* (0.21 ha.) fishpond. I have experienced the change of the local climate since childhood and seen the devastation caused by the floods in the Barpeta district.

Changing Climate

Over the years, the changes in the Climate are visible in my area. From own experience, I can say that temperature is gradually rising. We no more enjoy six seasons in a year (as mentioned in the book). We now distinctly experience only summer, rainy and winter. Summer is getting longer and winter shorter. Rain pattern is also changing and often getting erratic. Unseasonal rains and flash floods due to heavy rain in hilly areas are becoming common. Climate change leading to natural disasters, like flood and erosion, is affecting the livelihood options of people.

Floods Devastation

Despite floods being a natural phenomenon, human intervention has aggravated the problem over the years. The erection of river embankments touted as a solution, unfortunately has added to the increased devastation. Barpeta district is consistently one of the worst affected districts of Assam. Every year, the Beki, a major tributary of the Brahmaputra, inundate large areas of the district. This is not a one-day affair, but it goes for many days and in some cases many weeks. With most of the villages submerged, people rush to near-by school, bridge, road etc. with their belongings and put up the extent, often made of plastic sheets. People face problem in fetching drinking water. People use locally made rafts and boats for their movement. Villagers use flood water for cooking, drinking and bathing. This increases the risk of outbreak of water borne diseases like diarrhoea. Often the livestock like cattle, pig, goat etc. die in the flood water. But the chickens take shelter on the roof top. Vegetables gets scarce and people eat more fish during that period as availability of fish is more and price comes down.

Reasons of Floods

Assam and the north-eastern regions are prone to frequent earthquakes, which causes landslides. The landslides send a lot of debris in the rivers, causing river bed to rise and causing floods. Bank erosion is another destruction. Brahmaputra and its tributaries every year eat away lots of areas leaving thousands of farmers landless and homeless. It also increases the width of the river. Among the man-made reasons, the key cause of floods is release of water from dams situated uphill. Unregulated release of water floods the plains of Assam.

Floods destroy Aquaculture

Floods destroy fish ponds extensively. The flood water that inundates the fish ponds take away with it a variety of cultured fish from the pond, often good size fish ready for sale. Farmers try to protect their stock by encircling the fishponds with nets. It often fails to protect the stock as flood water keeps on rising. Fish farmers incur heavy financial loss. As of now, no crop insurance is available for fishery. Barpeta is a major fish producing district in Assam and in recent years, the district has not only become self-sufficient in fish seed production, but now supplying fish seed to other states also.

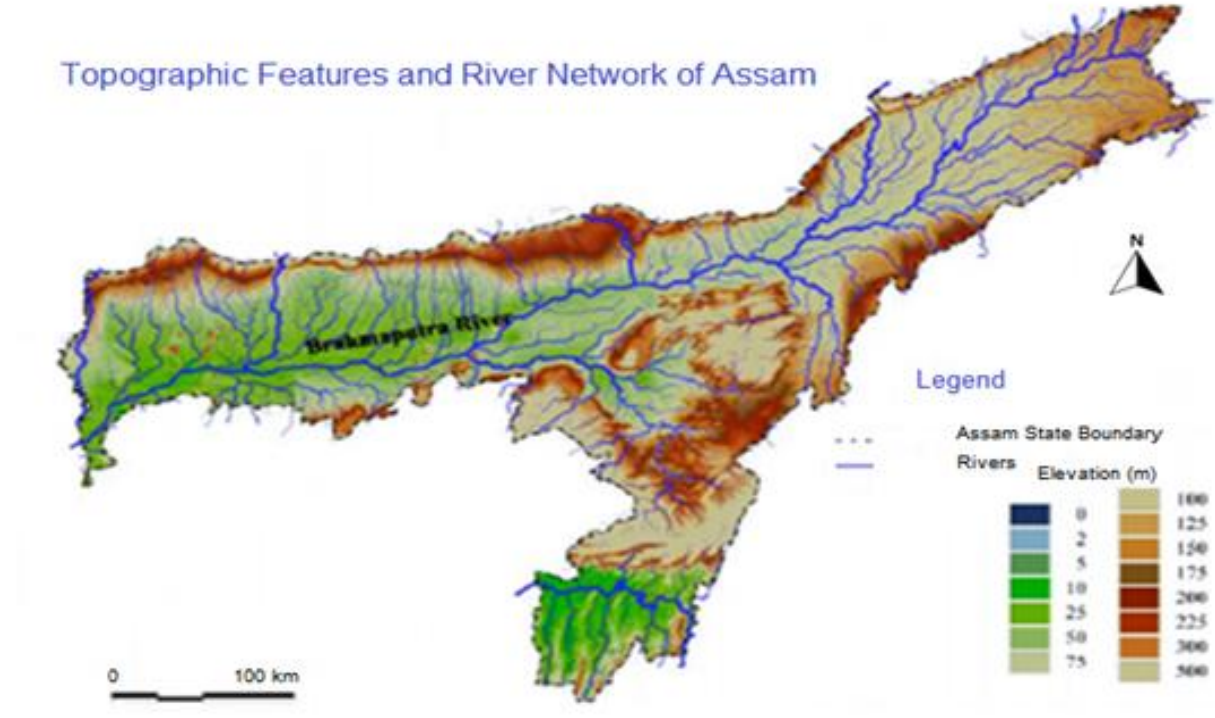
2.1.3.3 Climate Projections for Assam

District level climate projections are available across Assam for the period 2021–2050 and is driven by A1B scenario using regional climate model PRECIS, a model developed by the Hadley Centre, UK Meteorological office. The resolution of the model is 50km x 50km. It is to be noted that such projections are only indicative in the very broadest sense of the changes that are likely in the climate as high level of uncertainties are associated with the projections, indicating the need for further research on these aspects. Table 2.5 below shows the projected changes in various climate parameters till mid-century. Temperatures continue to rise and may increase by 1.7-2.0 C with respect to baseline. Only the western part of the State will experience slight decrease in rainfall but the rest of Assam is projected to have increase in rainfall. There is likely to be increase in extreme rain fall event by 5% to 38% with respect to baseline. Drought weeks are going to rise, with Southern

districts showing marginal reduction in drought weeks but rest of the district show an increase by more than 75% with respect to BL. As regards floods, they are going to rise by more than 25% in the southern parts of Assam.

Table 2.5 Projected Changes in the Climate of Assam

Climatic Parameters	Climate Projection for 2021-2050 w.r.t. to Baseline	Remarks
Mean Temperature	1.7-2.0 °C	All across Assam
Annual Rain fall	-5 to 5%	North western districts
	5-10 %	North Eastern districts
	10 – 25%	Central, South-Eastern District
Extreme rainfall days	5-38%	Rainfall > 25 to 150 mm
Drought weeks	-25% to > 75%	Southern districts show marginal reduction in drought weeks, but rest of the district show an increase by more than 75 % w.r.t. Baseline
Floods	Stream flow < 10% to > 25%	Min in north east and max in southern part of the state



Source: TARU 2011, adopted from Assam State Management Plan

Figure 2.4 Topographic Features and River Network of Assam

Table 2.6 Flood Hazard Areas of Assam

Severity of Hazard	Flood Hazard Area (ha)	% Flood Hazard	
		(of State Geographic Area)	(of total Flood Hazard Area)
Very High	1,28,687	1.64	5.79
High	2,24,629	2.86	10.11
Moderate	3,51,667	4.48	15.83
Low	4,91,761	6.27	22.14
Very Low	10,24,584	13.06	46.13
Total	22,21,328	28.31	100

(*Source:* Flood Hazard Atlas of Assam, ISRO 2011)

Table 2.7 Extent of Flood Hazard in Assam (1998-2007)

Affected Area (%)	No. of Districts	Name of Districts
70-80%	2	Darrang and Morigaon
60-70%	1	Barpeta
50-60%	1	Lakhimpur
40-50%	5	Dhemaji, Jorhat, Nalbari, Nagaon, Sibsagar
30-40%	6	Bongaigaon, Dhubri, Dibrugarh, Golpara, Kamrup(Rural), Sonitpur
20-30%	6	Cachar, Golaghat, Hailakandi, Kamrup (Metro), Karimganj, Udalguri
10-20%	2	Kokrajhar, Tinsukia
0-10%	4	Baska, Chirang, North Cachar, Karbi Anglong

(*Source:* Flood Hazard Atlas of Assam, ISRO 2011)

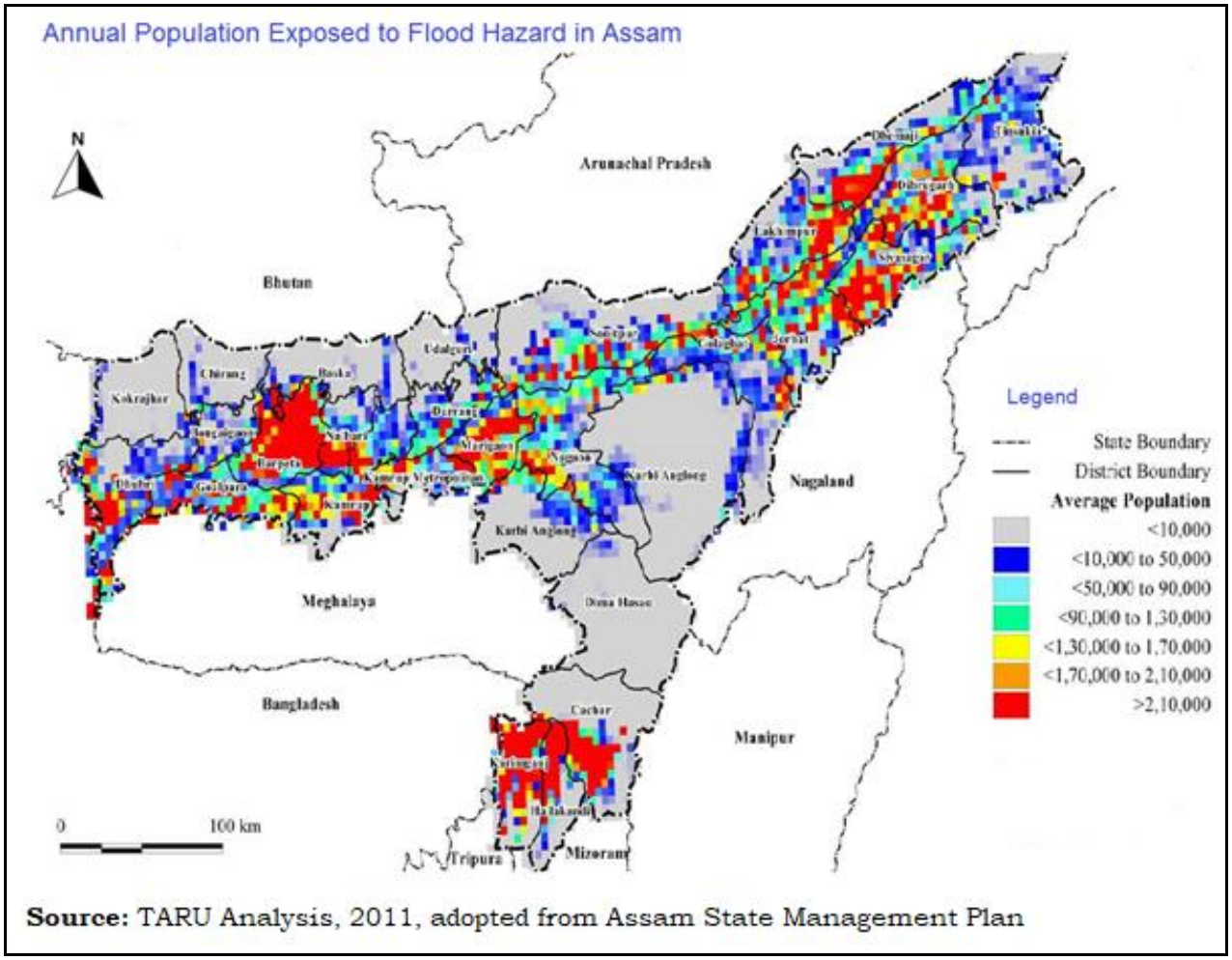


Figure 2.5 Expected Average Annual population exposed to Flood Hazard in Assam

2.1.3.4 Land Erosion and Accretion

The riverbank erosion has been a regular phenomenon in Assam. The history of land erosion in Assam indicates that between the years 1912 and 1996, around 868 sq. km. of land was lost to riverbank erosion; averaging to about 10.3 sq. km. of area lost per year. Nevertheless, accretion, the deposition of silt which is concurrent process leading to formation of new area in the north and south banks amounted to 303.84 sq. km and 246.32 sq. km. (total 550.16 sq. km.) respectively. The bank line of the Brahmaputra is consisting mostly of fine sands and silts which makes it extremely unstable. Further, the braided nature of the Brahmaputra adds unpredictability to erosion problem making it more serious.

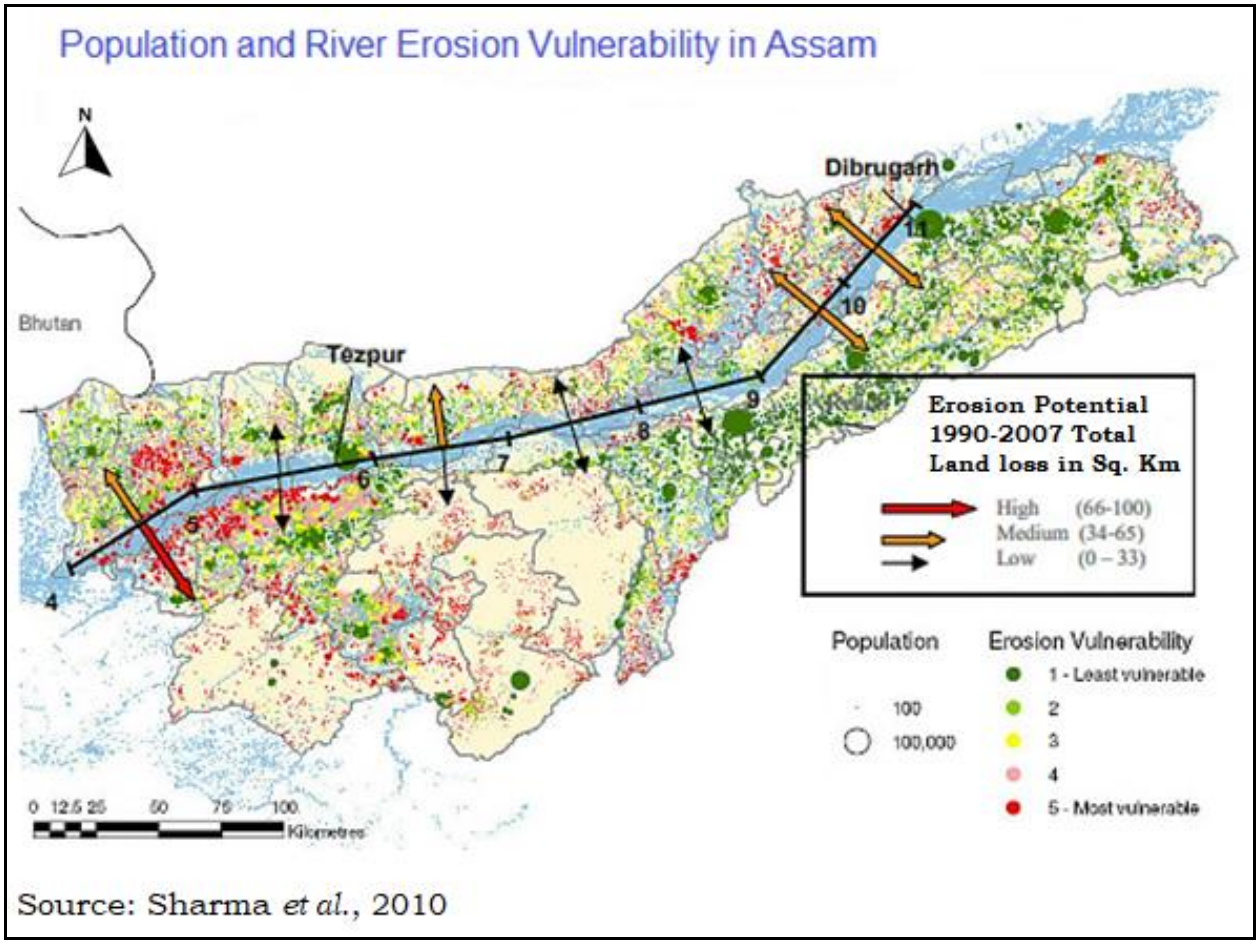


Figure 2.6 Total Populations and River Bank Erosion Vulnerability in Assam

2.1.3.5 Wind and Cyclone

Assam being an inland state is not prone to high intensity cyclone or wind speed. But the neighbouring country Bangladesh is highly prone to cyclone/winds and Assam is situated in its north eastern direction. Due to the location aspect, some districts of Assam like Dhubri, Goalpara, Hailakandi, Chachar and Karbi Anglong are somewhat prone to cyclone/winds. Occasional cyclones do occur in western Assam and their severity is more during monsoon. Districts very close to Bangladesh are in damage zone due to close proximity of Bay of Bengal (which is a cyclone basin). In this zone wind speed can reach up to 55 m/s, can result in large scale damage. The figure below indicates the wind speed zonation of Assam along with the tracks of the recent events of cyclones recorded within the state.

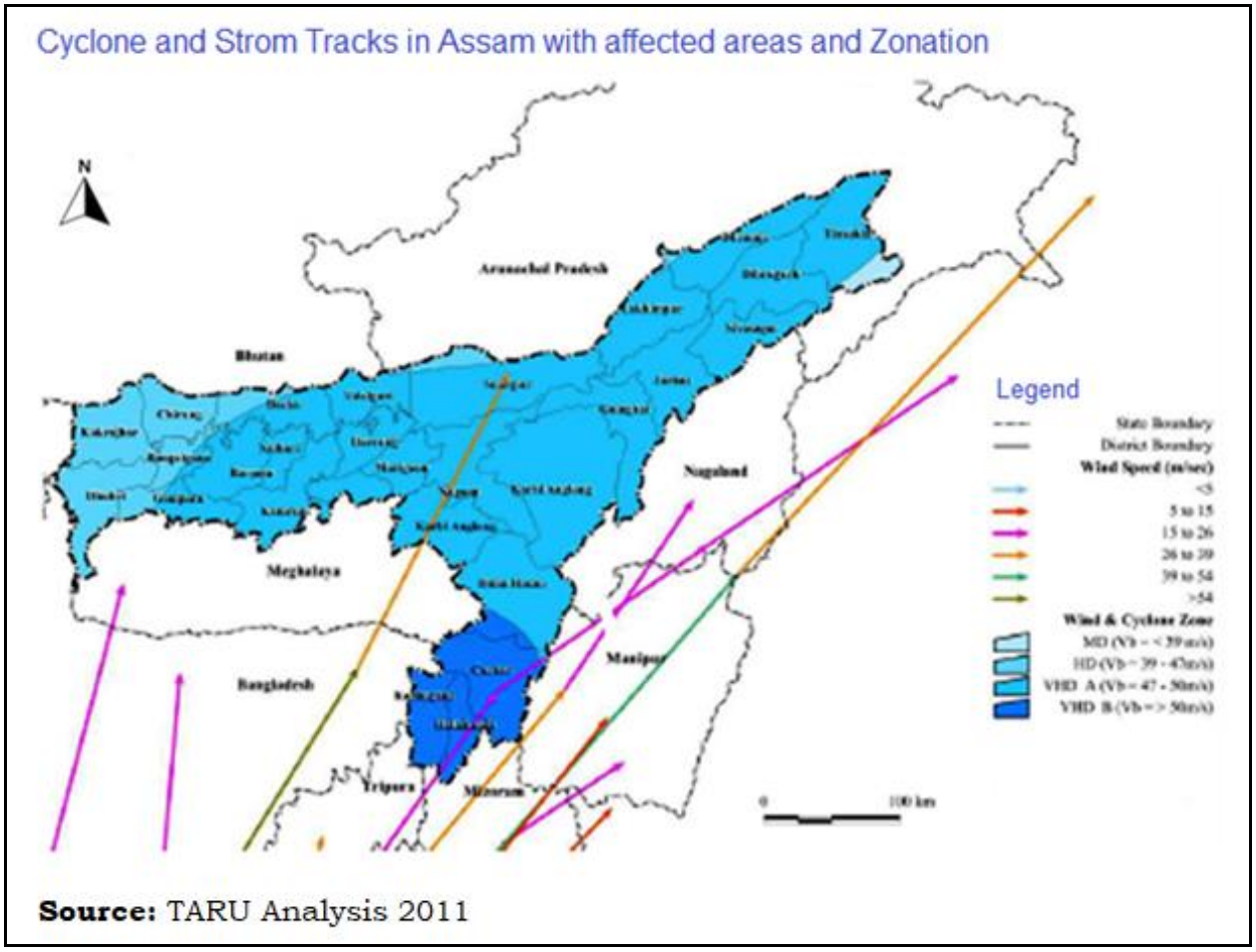


Figure 2.7 Cyclone and Storm Tracks in Assam with affected areas and zonation

2.1.3.6 Groundwater

Around 97% of the water on the Earth is salt water and only 3% is freshwater. The freshwater is the most precious natural resource for human, terrestrial animals and plants. Most of the freshwater is in icecaps and glaciers (69%) and groundwater (30%), while all lakes, rivers and swamps combined only account for a small fraction (0.3%) of the Earth's total freshwater reserves. Groundwater is the primary source of water for the people and the food production. Though freshwater is a renewable resource, yet the world's supply of groundwater is steadily decreasing, with depletion occurring most prominently in Asia including India. India is the largest user of groundwater in the world, using more than a quarter of the available global resources (Mukherjee, 2021). Increasing and unsustainable extraction of groundwater has resulted in significant depletion, with consequent adverse environmental impact. In India, gross per capita freshwater water availability is projected to decline from 1820 m3/yr. in 2002 to 1140 m3/yr. in 2050.

Almost in the entire state of Assam, the groundwater is available at low to a moderate depth. The Directorate of Geology and Mining, Govt. of Assam has categorized the quality of ground water as safe for drinking, industrial and

agricultural purposes. The pH value of ground water ranges from 7.5 to 9.0. All parameters are within the permissible limit except iron, fluoride and arsenic. Fluoride is present only in deeper aquifer. The annual groundwater draft in Assam is estimated to be 5.44 billion cubic meters (BCM) of which 4.85 BCM is for irrigation and 0.59 BCM is for domestic and industrial purposes (statistics of Central Ground Water Board, Govt. of India).

Table 2.8 Salient Features of Groundwater Resources of Assam

A.	**Ground Water Availability**	
1	Annual Replenishable Groundwater Resource	27.23 BCM
2	Net Annual Groundwater Availability	24.89 BCM
3	Stage of Groundwater Development	22 % (lowest 2% in Cachar District and highest 56% in Bongaigaon District
B.	**Groundwater Exploitation Level**	
1	Over Exploited	NIL
2	Critical	NIL
3	Semi-critical	NIL
C.	Groundwater Quality Problems	
1	Contaminants	Districts affected (in part)
2	Fluoride (>1.5 mg/l)	Goalpapra, Kamrup, Karbi Anglong, Nagaon,
3	Iron (>1.0 mg/l)	Cachar, Darrang, Dhemaji, Dhubri, Goalpapra, Golaghat, Hailakandi, Jorhat, Kamrup, Karbi Anglong, Karimganj, Kokrajhar, Lakhimpur, Morigaon, Nagaon, Nalbari, Sibsagar, Sonitpur
4	Arsenic (>0.05 mg/l)	Dhemaji

(*Source:* Central Ground Water Board, Govt. of India)

The relationship between the changing climate variables and groundwater is more complicated and poorly understood. Groundwater resources are related to climate change through the direct interaction with surfacewater resources, such as wetlands and rivers, and indirectly through the recharge process. The effect of climate change on groundwater resources depends upon the change in the volume and distribution of groundwater recharge. Climate change does not only affect groundwater quantity, but also its quality. A number of Global Climate Models are

available for understanding climate and projecting climate change. There is a need to downscale these models on a basin scale and couple them with relevant hydrological models considering all components of the hydrological cycle. Output of these models such as quantification of the groundwater recharge will help in taking appropriate adaptation strategies due to the impact of climate change on groundwater. Groundwater depletion is a serious threat to the environment. Groundwater depletion commonly occurs because of the excessive pumping of water from the ground for agriculture, aquaculture and other purposes, and it does not have enough time to replenish itself.

2.2 Fisheries activities in Assam

2.2.1 Fishery Resources of Assam

Being blessed with huge fishery resources and having excellent tropical climate with average annual rainfall of over 1500 mm, Assam is one of the most potential states in India for the development of fisheries. The state has vast river network of 4820 km contributed by two major river systems (Brahmaputra and Barak) with 53 tributaries. As per the estimate of 2019-20, excluding the riverine resource, the state has total fishery resources of 0.244 million ha comprising of floodplain wetlands/*beels* (62,659 ha), derelict water bodies/swamps/low-lying areas (98,354 ha), forest fisheries (4802 ha), reservoirs (1096 ha), and ponds & tanks (77,250 ha).[1] Despite the vast aquatic resources, Assam has not been able to produce sufficient fish to attain self-sufficiency and still import fish from other states of India. In the year 2019-20, Assam imported 20,073 metric tonnes of fish and exported 9737 metric tonnes of fish with a net deficit of 10,336 metric tonnes. Fish occupies a prominent place in the lives and livelihoods of the people of the State and fish farming is one of the common activities in the rural areas. Apart from this, capture fisheries and aquaculture provide livelihoods for thousands of rural households, who are directly or indirectly involved in the production and allied value chain activities. The current level of productivity from the ponds and *beels* of Assam is far below the potential productivity. The current average productivity in ponds is around 1,680 kg/ha/yr., while *beel* fisheries produce less than 500 kg/ha/yr. Therefore, Assam Government is making all efforts to augment the fish production of the state through horizontal and vertical expansion. The horizontal expansion is being accomplished through creation of new ponds and reclamation and renovation of existing areas for fish culture. On the other hand, in vertical expansion emphasis is on productivity enhancement through adoption of improved culture practices and better management practices. The launching of World Bank assisted 'Assam Agribusiness and Rural Transformation Project (APART)' with fisheries as a sub-component in the year 2018 is a step in this direction. WorldFish is the technology partner of the project and extending the technical support

through its international experience and expertise. One of the objectives of the project is to develop and promote climate-resilient technologies in support of sustainable aquaculture and small-scale fisheries. The positive impact of APART is evident from the fact that in the year 2020, the Assam state begged four top national level awards in the fisheries sector such as best state, best district, best Govt. organisation and best farmer from Govt. of India in "Hilly and North Eastern" category.

In Assam, fish comes from two main modes of production systems; aquaculture (farming fish in ponds and tanks) and *Beel* fisheries (capturing fish from floodplain wetlands). Other sources like riverine fisheries, production from miscellaneous sources constitute a small portion. Therefore, the policies and strategies for increasing fish production in the state are centered around aquaculture and *Beel* fisheries. The present study also covers the above two areas only.

2.2.2 Trends in Fish and Fish Seed production

Assam ranks first in fish production among North-eastern states of India. Since there is no marine fish production, the contribution of the state to the total fish production of the country is very less. However, of late, the state has shown impressive growth in fish production. In last five years (from 2016-17 to 2020-21), the state has registered an increase of 28.4% in fish production and a spectacular 74.11% rise in fish seed production.

Table 2.9 Fish and Fish Seed Production of Assam in comparison to India

Year	Total Fish Production (million metric tonnes)		Contri-bution of Assam (%)	Total Fish Seed Production (million fry)		Contri-bution of Assam (%)
	India	Assam		India	Assam	
2005-06	6.572	0.187	2.85	21988	3208	14.59
2006-07	6.869	0.181	2.64	23648	3062	12.95
2007-08	7.127	0.190	2.67	24144	3206	13.28
2008-09	7.616	0.206	2.70	32177	3429	10.66
2009-10	7.998	0.218	2.73	29313	3326	11.35
2010-11	8.231	0.232	2.82	34109	4263	12.50
2011-12	8.666	0.243	2.80	36565	3624	9.91
2012-13	9.040	0.254	2.81	34920	4364	12.50
2013-14	9.579	0.266	2.78	41448	4546	10.97
2014-15	10.069	0.282	2.80	39348	4585	11.65
2015-16	10.762	0.294	2.73	35435	5678	16.02
2016-17	11.431	0.306	2.68	35743	6758	18.91
2017-18	12.704	0.321	2.53	44420	8000	18.01

2018-19	13.573	0.331	2.44	48197	9893	20.53
2019-20	14.164	0.335	2.37	52170	9519	18.25
2020-21	-	0.393*	-	-	9886*	-

* Provisional data obtained from Department of Fisheries, Govt. of Assam

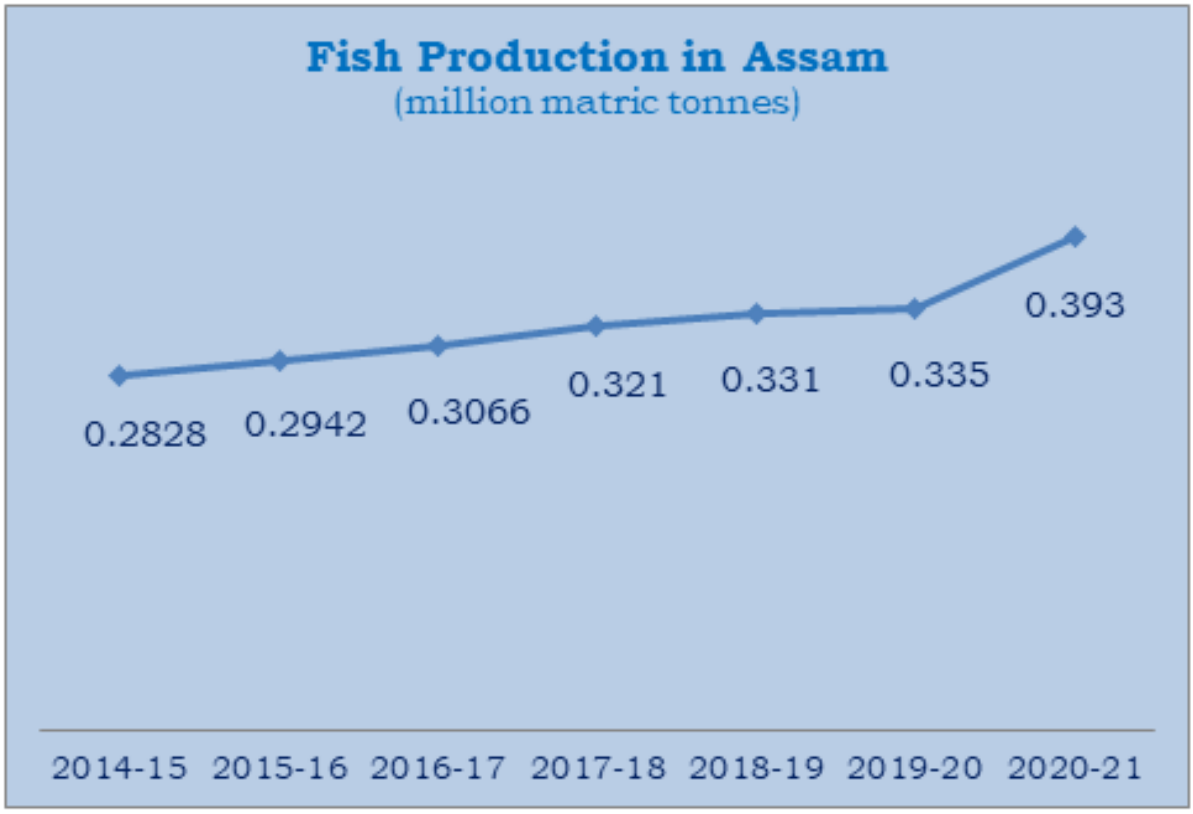


Figure 2.8 Graph showing steady increase in fish production of Assam over recent years

Table 2.10 Analysis of Fish Production, Demand-Supply and External Trade in Assam

Year	Fish production, demand & gap (in thousand metric tonnes)			Fish Import & Export (in metric tonnes)	
	Production	Demand	Gap	Fish Import	Fish Export
2015-16	294	336	42	14825	7792
2016-17	307	342	35	12618	11421
2017-18	327	348	21	11357	9419

2018-19	331	354	23	12641	8308
2019-20	373	393	20	20073	9737
2020-21	393	399	06	12829	11694

There is a clear sign of significant improvement in fish production as well as in fish seed production of the state in the year 2020-21 over the preceding year (2019-20) which may be attributed to success of APART and other projects being implemented in the fishery sector. The year 2020-21 witnessed an increase of 5.36 % in fish production and a rise of 3.86 % in fish seed production over the previous year.

Table 2.11 District-wise Fish and Fish Seed Production of Assam in 2020-21

Sl. No.	District	Fish seed (fry) (Production in million No's)			Fish production (Metric Tonnes)		
		Govt.	Private	Total	Govt.	Private	Total
1	Barpeta	0.00	47389.00	47389.00	0.16	26114.85	26115.01
2	Baksa	0.00	674.00	674.00	0.00	8328.00	8328.00
3	Bongaigaon	0.00	145.00	145.00	0.00	9450.00	9450.00
4	Cachar	3.07	440.00	443.07	0.00	36148.00	36148.00
5	Chirang	0.00	70.00	70.00	0.00	1828.00	1828.00
6	Darrang	9.75	353.40	363.15	0.00	13910.00	13910.00
7	Dhemaji	0.00	0.00	0.00	0.00	10166.50	10166.50
8	Dhubri	0.00	367.80	367.80	0.00	15633.32	15633.32
9	Dibrugarh	1.50	63.30	64.80	0.00	14091.84	14091.84
10	Goalpara	0.00	345.00	345.00	0.00	10897.00	10897.00
11	Golaghat	0.00	29.96	29.96	0.00	7677.60	7677.60
12	Hailakandi	0.00	190.00	190.00	0.00	14774.73	14774.73
13	Jorhat	0.00	442.00	442.00	0.41	13319.02	13319.43
14	Kamrup	0.00	619.16	619.16	0.00	25555.20	25555.20
15	Karbi Anglong	2.09	0.00	2.09	0.00	4419.34	4419.34
16	Karimganj	0.00	22382.10	22382.10	0.00	14316.60	14316.60
17	Kokrajhar	0.00	167.27	167.27	0.00	8337.64	8337.64
18	Lakhimpur	0.00	1585.24	1585.24	0.19	16602.00	16602.19
19	Morigaon	0.00	1527.70	1527.70	0.00	21709.07	21709.07
20	Dima Hasao	2.00	0.00	2.00	0.00	631.00	631.00

21	Nagaon	1.50	17773.50	17775.00	2.40	52717.79	52720.19
22	Nalbari	0.00	1002.00	1002.00	0.00	13602.00	13602.00
23	Sibsagar	2.65	625.40	628.05	0.00	12689.68	12689.68
24	Sonitpur	3.00	1701.50	1704.50	0.00	13815.00	13815.00
25	Tinsukia	0.00	720.00	720.00	0.00	23282.20	23282.20
26	Udalguri	0.00	223.00	223.00	0.00	2967.50	2967.50
	Total	**25.26**	**98836.33**	**98861.89**	**3.16**	**392983.88**	**392987.04**

2.2.3 Categorization of districts in Assam based on fish and fish seed production

Currently Assam has total 34 administrative districts after the latest bifurcation in 2020. However, for the purpose fishery development, the State Fishery Department has 26 districts as some of the divided districts are still considered as undivided districts. Based on the district-wise data of 2020-21 on fish and fish seed production; an attempt was made to develop colour gradient map of Assam for fish and fish seed production. The districts are grouped into three categories depending on the level of production, *i.e.,* high production, medium production and low production and for each district ranks are allotted. The districts having the annual fish production of more than 20,000 metric tonnes are grouped as high fish production districts and six districts namely Nagaon, Cachar, Barpeta, Kamrup, Tinsukia and Morigaon (in decreasing order) constituted that group. Another twelve districts namely Lakhimpur, Dhubri, Hailakandi, Karimganj, Dibrugarh, Darrang, Sonitpur, Nalbari, Jorhat, Sivsagar, Goalpara and Dhemaji came under medium fish production districts (in decreasing order) with the annual fish production hovering between 10,000 and 20,000 metric tonnes. Rest of the districts namely Bongaingaon, Kokrajhar, Baksa, Golaghat, Karbi Anglong, Udalguri, Chirang and Dima Hasao (in decreasing order) are the low fish production districts with the annual fish production of less than 10,000 metric tonnes.

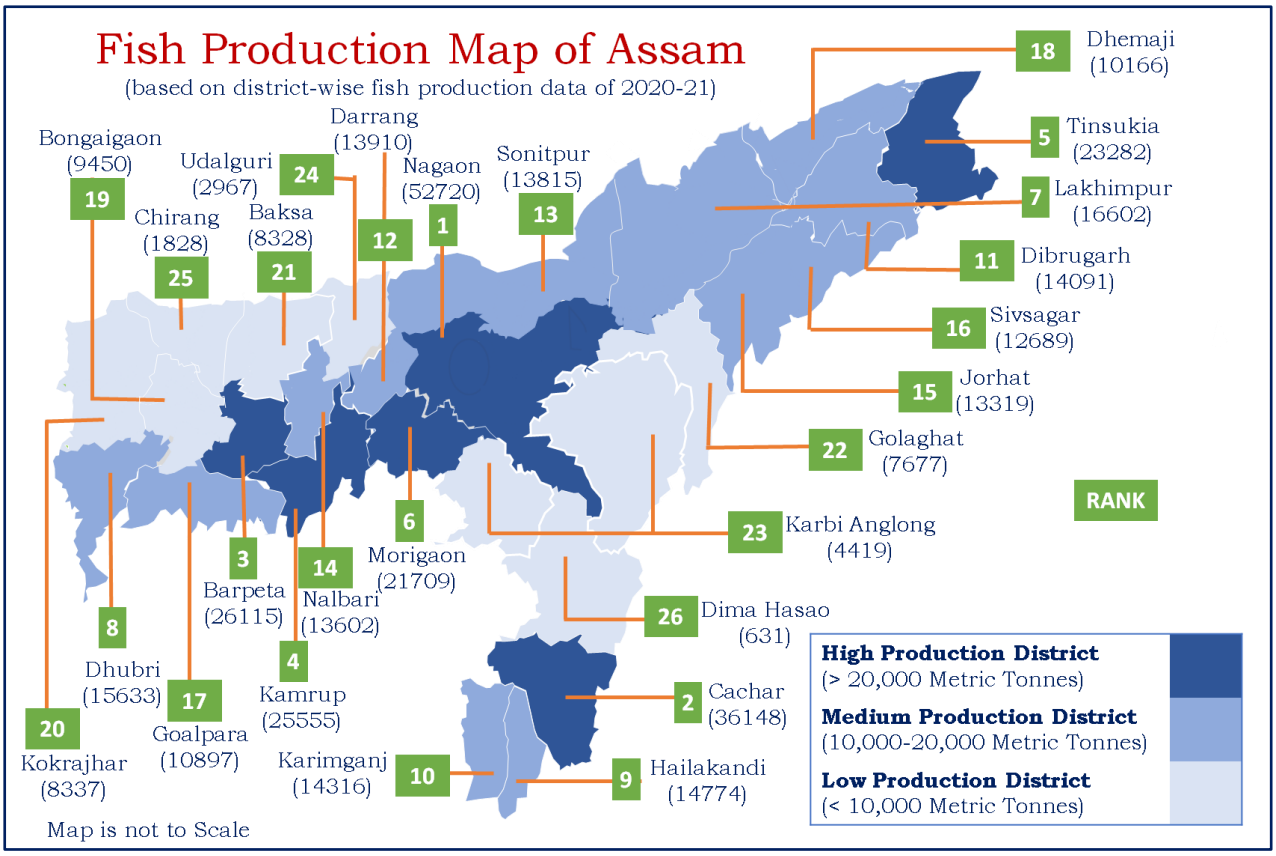


Figure 2.9 Colour gradient map of Assam showing district-wise fish production in 2020-21

Assam is one of the major fish seed producing states in India and contributes to around 20% of the total seed production of the country. The state has 499 fish hatcheries at present in different districts that produced 98862 million fry in 2020-21 which is an all-time high. It is a fish seed surplus state and is supplying fish seed to the neighbouring states in North East. Barpeta, Karimganj and Nagaon districts are the fish seed production hub of the state and they contribute about 88% of the total fish seed production of the State. The fish seed production map of Assam in colour gradient is furnished below for easy understanding.

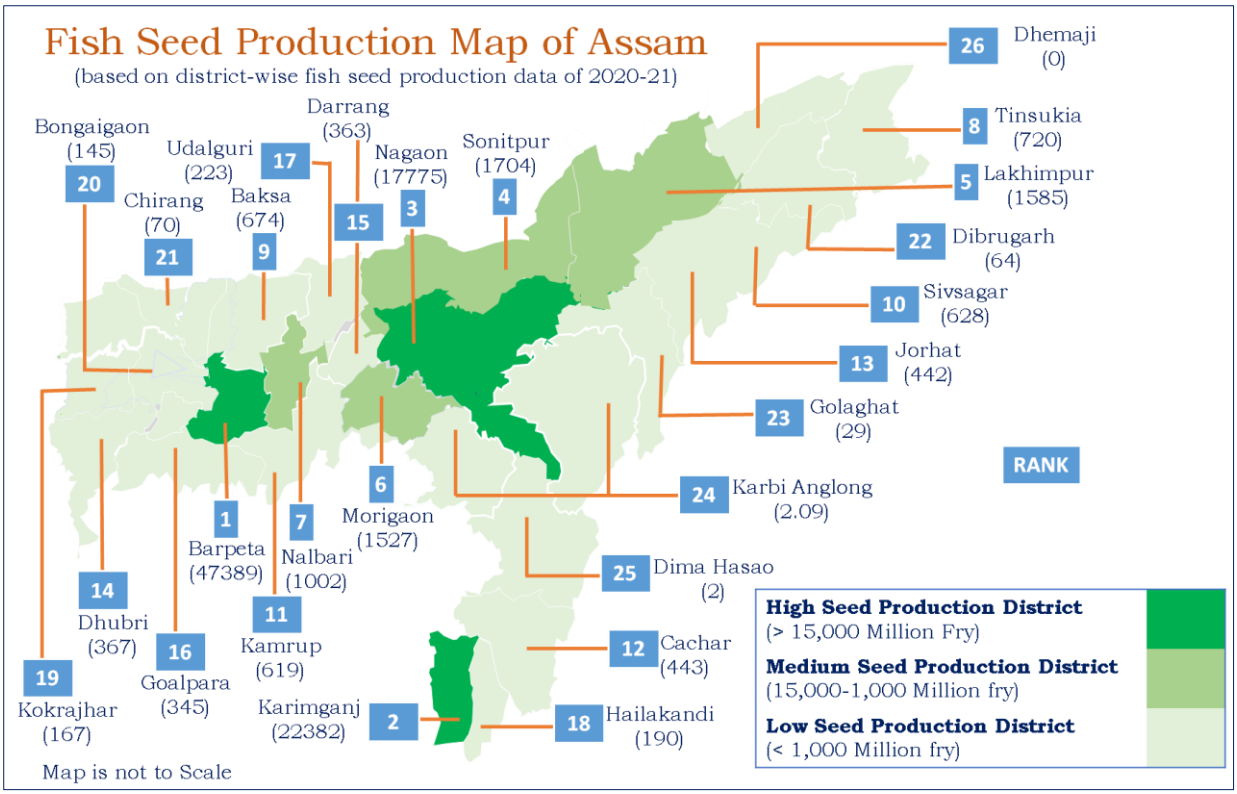


Figure 2.10 Colour gradient map of Assam showing district-wise fish seed production in 2020-21

2.2.4 Fish Consumption in Assam

Assam is predominantly a fish-eating state with over 90% of the population consuming fish. Assam has the distinction of being one among the top five states of India with highest per capita consumption of fish. With the increase in fish production, the state has witnessed a sharp rise in fish consumption also. In the last five years, per capita consumption of fish in Assam has risen from 8.5 kg to 11.88 kg per annum. Fish and fishery products including dry fish and other traditional fermented items play a critical role in the food security and nutritional needs of people in Assam. It is a well-known fact that the consumption of fish provides energy, protein, wide range of essential micronutrients including vitamins and minerals and a host of other health benefits. The small indigenous species consumed whole with heads and bones, provide excellent source of micronutrients such as vitamins and minerals. Despite all these benefits, the annual per capita fish availability in the state is relatively low. With increase in production, the per capita fish consumption is likely to grow further in the near future. The driving force behind this surge will be a combination of population growth, rising incomes, strong affinity of the consumers to fish amongst the animal proteins, urbanization interlinked to the expansion of fish production and modern distribution channels, etc. Further, it is interesting to note that, the demand for locally produced fish is always higher than the imported fish (locally called as *Salani*) in Assam and at all

times, the local fishes fetch better price. This is due to the quality, freshness and better taste of the locally produced fish.

2.2.5 Major Schemes implemented in Assam during the last five years

Government of Assam considers fisheries as one of the promising sectors and recognizes this sector as a source of income and employment generation. The schemes of the Government are seen to be having perceptible impacts on the growth of the sector. The Department has fixed the fish production target of 5.73 lakh Metric Tonnes by 2026 along with doubling of farmers' income and per capita availability of fish @ 15 Kg. To achieve these targets, all Centrally sponsored schemes, externally aided projects and schemes under State own funds are to be implemented properly in the farmers' field. In the last five years, the Government of Assam has implemented the following major schemes for development of fisheries sector.

- Centrally Sponsored Schemes of Pradhan Mantri Matsya Sampada Yojana (PMMSY) and Blue Revolution (BR)
- Ghare Ghare Pukhuri Ghare Ghare Maach (GGPGGM) scheme under the aegis of NABARD assisted Rural Infrastructure Development Fund (RIDF)
- Chief Minister's Samagra Grammya Unnayan Yojana (CMSGUY)
- World Bank assisted Assam Agribusiness and Rural Transformation Project (APART)
- Centrally Sponsored Scheme of Rastriya Krishi Vikash Yojana (RKVY)
- State Own Priority Development Fund (SOPD)

2.2.5.1 Pradhan Mantri Matsya Sampada Yojana (PMMSY): PMMSY is a Centrally Sponsored Scheme designed to address critical gaps in fish production and productivity, quality, technology, post-harvest infrastructure and management, modernisation and strengthening of value chain, traceability, establishing a robust fisheries management framework and fishers' welfare. In the year 2020-21, projects worth Rs. 11021.90 Lakh was approved for for implementation in Assam under PMMSY with central contribution of Rs. 5113.57 Lakh, state contribution of Rs. 634.84 Lakh and beneficiary contribution of Rs. 5273.49 Lakh. The implementation of the projects is at different stages. For the development of aquaculture, 10 fish hatcheries, 34 feed mills (small & large), 100 ha of seed rearing ponds, 205 ha of grow-out ponds, 20 ornamental fish rearing units, 20 RAS units, 40 biofloc units are being constructed. Similarly for the development of *Beel* fisheries, activities like stocking fingerling in 1580 ha, installation of 150 cages and erection of pens in 60 ha are being taken up. For strengthening the fish transport and marketing, 10 refrigerated vehicles, 5 insulated vehicles, 100 motorcycles with ice box, 135 e-rickshaws with ice box are

being procured. In addition to these, 10 live fish vending centres and 22 fish kiosks are also developed.

2.2.5.2 Ghare Ghare Pukhuri Ghare Ghare Maach (GGPGGM) Scheme: This scheme is launched by Fisheries Department of Assam with funding assistance from NABARD through Rural Infrastructure Development Fund (RIDF). The English translation of this scheme is 'pond for every family and fish for every family'. Total outlay of the project is Rs. 12155.00 lakh out of which Rs. 9509.50 lakh is the loan component offered by NABARD. The State Govt. share is Rs. 500.50 lakh and the beneficiary contribution is Rs. 2145.00 lakh. So far, the Fisheries Department has extended benefit to 376 Community Tank groups and 9050 individuals with ponds covering total waterspread area of 1430 ha. The Govt. has set the target of producing 5000 metric tonnes (MT) of additional fish annually through this scheme. To boost fish feed production in the state, 5 medium fish feed mills and 44 small fish feed mills will be commissioned in the state under the scheme for producing more than 6000 MT of fish feed annually. For transportation and hygienic marketing of fish, 70 Four-wheeler refrigerated vehicles and 351 Three-wheelers - with ice boxes will be also procured.

2.2.5.3 Chief Minister's Samagra Grammya Unnayan Yojana (CMSGUY): Under this scheme, training and critical inputs like fish seed and feed are being given to the beneficiaries of *Ghare Ghare Pukhuri Ghare Ghare Maach.* An amount of Rs. 100.00 lakh was released to College of Fisheries, Raha (Assam Agricultural University). Training has already been imparted to 30 batches of farmers (total about 1500) from different districts so far by the College of Fisheries and Krishi Vigyan Kendras. It is expected that the remaining 500 farmers will be receive training within September, 2021. Further, more than Rs. 400 lakhs have been released to about 3800 beneficiaries through direct benefit transfer (DBT) for procurement of fish seed and fish feed. It is expected that by March, 2022, all beneficiaries will receive funds under CMSGUY for procurement of fish seed and feed. In *Beel* fisheries, out of 38 *Beels* targeted for Cage Culture in *Beels* during 2019-20 and 2020-21, installation of 28 batteries of HDPE modular cages (280 cages) have already been completed in 28 different *Beels* and 10 batteries of cages will be installed shortly.

2.2.5.4 Assam Agribusiness and Rural Transformation Project (APART): The Department of Fisheries is implementing the fishery component of World Bank assisted APART through ARIAS Society from the year 2017-18 in 15 selected districts of Assam. Under the polyculture demonstration**,** 2388 beneficiaries with 985 ha water area have been covered in 14 districts till date. Similarly, under the scheme paddy cum fish culture, 916 beneficiaries with 443 ha in 9 districts have been covered till date. So far 748 ha of *beel* fisheries have been taken up for development. Polyculture with freshwater prawn covering 20 ha is under progress

in Kamrup, Nalbari and Goalpara districts. In addition to these, hatchery up-gradation programme for quality fish seed production is taken up in 5 Departmental farms and 4 multiplication centres for genetically improved fish strains Jayanti rohu and Amur common carp have been developed. 10 Mini Fish Feed Mills and 10 hygienic fish marketing units are under establishment. Upon completion of APART, output in the form of 3800 MT of table fish and 600 lakh of fish seed (fry) are expected to be produced additionally.

2.2.5.5 Rastriya Krishi Vikas Yojana (RKVY): RKVY is a centrally sponsored scheme which was started in 2007 for ensuring holistic development of agriculture and allied sectors including fisheries. Since 2017, the scheme is being implemented as Rashtriya Krishi Vikas Yojana – Remunerative Approaches for Agriculture and Allied Sectors Rejuvenation (RKVY-RAFTAAR). In 2019-20, Rs. 422.22 Lakh was sanctioned and released to the Fishery Department of Assam. Major achievements under RKVY during 2017-18 to 2019-20 are:- Construction of new pond (52 ha), renovation of existing ponds & tanks for fish culture (56 ha), conversion of low lying areas to community tank (65 ha), establishment of magur hatcheries in departmental farm (2 nos.), establishment of carp hatcheries (5 nos.), renovation and up-gradation of training centres of Fisheries Department (6 nos.), renovation and up-gradation of 2 Departmental farms (2 nos.), distribution of water testing kit to field staff (210 nos.), and training and exposure visit of farmers (1000 nos. in 40 batches). The ongoing activities under RKVY are:- development of *beel* fisheries in the vested Govt. land for community based management (45 ha), community based cage culture in *beels* (20 cages in 2 *beels*), distribution of aerator to progressive fish farmers (110 nos.), refrigerated fish/fish seed transport 4-wheeler van (5 nos.), setting up of mobile fish outlets (5 nos.), supply of cast nets and ice box & bicycles to the member societies of FISHFED (600 nos.) and strengthening of Departmental State Fish Laboratory.

2.2.5.6 State Owned Priority Schemes (SOPD): Under SOPD in the last 2 years, the Department has constructed 5 Hygienic fish markets (Hailakandi, Jorhat, Lakhimpur, Morigaon and Dhemaji) and 2 Fish retail outlets (Nagaon and Cachar). Fishery Eco-Tourism Development programme has been taken up in Lokapriya Gopinath Bordoloi Tank near Meen Bhawan, Guwahati and was completed in February, 2021. The Department has provided Grants-in-aid to AFDC Ltd for Creation of Capital Asset through development of *beel* fisheries (SOPD). A Research Project on Gene Bank project is under implementation through College of Fisheries, Raha for a period of 5 years. FISHFED was provided Grants-in-aid for extending development support in fisheries. During 2021-22, under SOPD emphasis is mainly laid on the Gene Bank Project titled 'Scientific Conservation Programme of Indigenous Fishes' (SCoPIF) for conservation of indigenous endangered fishes, being implemented by College of Fisheries, Grants-in-Aid to AFDC and FISHFED,

fish and fish seed production in 12 departmental farms, distribution of fish culture inputs to SC & ST farmers for enhanced production, construction of 4 ongoing fish markets (at Bongaigaon, Barpeta, Goalpara and Dhubri) and a fish retail outlet at Guwahati. Under Fisheries extension service, activities like re-engagement of 77 Matsya Mitras as support extension workers besides organizing workshop on fishery related activities and awards to fishers and farmers, etc. have been taken up.

2.2.6 SDGs relevant to Fisheries Sector in Assam

Sustainable Development Goals (SDGs) are a collection of 17 global goals set by the United Nations General Assembly in 2015. The SDGs are part of Resolution 70/1 of the United Nations General Assembly which says 'Transforming our World: the 2030 Agenda for Sustainable Development'. To achieve sustainable development at all fronts, it is imperative that the State Action Plan on Climate Change (SAPCC) for Assam is aligned with SDGs. In the light of the above, the Assam SAPCC, inter alia, ensures the sustainability of agriculture systems (with different sub-sectors like crops, livestock, fisheries) to provide livelihood security in the changing climate scenario. Fisheries is amongst the top sectors vulnerable to the climate change. Therefore, to attain sustainable development in fisheries for the state, it is necessary to examine the different facets of the fisheries through the lenses of SDGs. This will help in devising appropriate adaptation and mitigation strategies for ensuring adequate aquatic food production, equitable access to nutrition, enhancing livelihood opportunities and contributing handsomely to the state economy. The below mentioned table analyses the pertinent SDGs having relevance to fisheries sector of Assam.

Table 2.12 Sustainable Development Goals (SDGs) and relevant areas in Aquatic Food Production System of Assam

SDG Logo	Description	Relevant areas in Aquatic food production system of Assam
	SDG **1** No Poverty	Culture and capture fisheries help small-scale fish farmers and fishers respectively to earn an income
	SDG **2** Zero Hunger	Aquaculture being a three-dimensional farming has higher productivity. Aquaculture & inland capture fisheries boost the household consumption of fish.
	SDG 3 Good health & well-being	Fish is a nutritious food and regular consumption of fish combats malnutrition and promotes good health and well-being.
	SDG **5** Gender Equality	Culture and capture fisheries involve women participation leading to their financial empowerment. It leads to gender equality.

	SDG **8** Decent work and Economic Growth	Culture and capture fisheries provide opportunities for decent work with good economic returns.
	SDG **10** Reduced Inequalities	Culture and capture fisheries help to earn and invest in other avenues. It generates job opportunities and promotes employment leading to reduced inequalities.
	SDG **13** Climate Action	Adaptation and mitigation strategies for climate resilient culture and capture fisheries, mainstreaming climate measures in state policies; imparting awareness and education on climate change; building capacities of individuals and institutions; etc. come under climate action.
	SDG **14** Life Below Water	Pursuing sustainable water-based livelihood, protecting and restoring the aquatic resources and biodiversity, prevention of invasive alien species, etc. contribute to safeguard life below water
	SDG **17** Partnership For The Goal	Stakeholder engagement and partnership building in fisheries; learning, training and practices on sustainable development in fisheries lead to partnership for sustainable development goal.

2.2.7 Aquaculture in Assam

Aquaculture is the fastest growing food production system in the world and this trend is going to continue. Aquaculture in Assam, being a land-locked state, is confined to freshwater only. Traditionally culture of fish in Assam was developed in freshwater as polyculture of Indian major carps of catla (*Catla catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*). This was mainly because culture operation entirely depended on the wild mixed seeds of carps, which were collected from the rivers during monsoon when they bred and farmers had no means to segregate them. Until the late nineteenth century, carp culture in Assam was confined to homestead ponds only. In 1957, hatchery and induced breeding technologies were developed in eastern India and this provided the impetus for a new era of carp farming. Introduction of three other exotic carps namely grass carp (*Ctenopharyngodon idella*), silver carp (*Hypophthalmicthys molitrix*) and common carp (*Cyprinus carpio*) as components of Composite fish culture (Polyculture of Indian and Chinese carps) has resulted in enhancing the productivity of freshwater aquaculture. Over the years, farmers of Assam have learnt better culture practices and aquaculture has expanded its dimensions in terms of area coverage and intensity of operation. Gradually other species such as *Labeo gonius*, *Labeo bata*, *Clarias batrachus*, *Heteropneustes fossilis, Anabas testudineus, Channa striata, Channa marulius, Ompok pabda, Puntius sarana*, etc. are being cultured. In recent years, some farmers are also culturing exotic species like Pangasius (*Pangasianodon hypophthalmus*), nile tilapia (*Oreochromis niloticus*), pacu

(*Piaractus brachypomus*) etc. Of late, with the technical guidance of WorldFish, the culture of self-recruiting species of *Amblypharyngodon mola* and the high value freshwater prawn species *Macrobrachium rosenbergii* is gaining acceptance amongst the farmers of Assam. Fishponds in Assam are mostly small ponds of less than 1 ha in size and predominantly used for local consumption. Therefore, the social impact of the small holders' aquaculture for the food and livelihood security is quite high.

Table 2.13 Categorization of Fishponds and their ownership in Assam

Sl.	Category of pond	Size of pond (ha)	Production System	Ownership and resources
1	Small size pond	< 0.1	Low-input System	Rural poor with meagre / some resources
2	Medium size pond	0.1-1.0	Medium-input System	Rural farmer with adequate resources
3	Large size pond	> 1.0	High-input System	Enterprising farmer with enough resources
4	Community / Village Pond	Varying size	Low to Medium input system	Village, Religious Institution, Local Self- Govt. etc. with/without resources

2.2.8 Strategies for Aquaculture Development in Assam

The main fish production strategy, horizontal expansion is being accomplished through creation of new ponds and reclamation and renovation of existing ponds. On the other hand, thrust on vertical expansion is given through productivity enhancement with adoption of improved culture practices and better management practices. Increasing the productivity of the aquaculture pond through climate-resilient technologies is one of the objectives of the APART Project. These technologies include in-situ modification of the various inputs of the fish farming system in the forms of species diversification, system diversification, stock improvement, breed improvement, etc.

2.2.8.1 Species Diversification: Aquaculture in Assam is mainly carp-based. Since carp is not a high-valued fish, one of the possible ways to make the aquaculture more remunerative for the farmers, is inclusion of high valued species into the carp culture system. Fortunately, Assam is blessed with rich diversity of potential cultivable fish fauna which includes minor carps and barbs, murrels, catfish, self-recruiting small indigenous species, etc. The seed production and grow-out culture technologies for some of these species have already been standardized. Introduction of these species in the conventional carp polyculture

and exclusive culture of these species in seasonal ponds will be more rewarding for the farmers.

2.2.8.2 System Diversification: In Assam, the characteristics of water resource for aquaculture vary in the agro-climatic zones and also within the districts of same agro-climatic zone. Aquaculture should exhibit wider flexibility with regard to species and input use for utilizing these resources effectively as per the local requirement. Therefore, emphasis should be on location-specific, climate resilient and farmer-centric technologies. For example, on regional basis, seed rearing clusters can be formed using few perennial ponds with relatively less water depth to cater round the year supply of seed to the grow-out ponds of the region for practicing multi-stocking-multi harvest method of fish farming. This would also lead to more effective utilization of ponds in the flood-prone area through short duration fish farming through use of stunted seed. Similarly, deep-water rice-fish integration system can be advocated in low-lying water-logged areas with suitable location-specific refinements. Integrated farming with livestock and/or agri-horticultural components is popular in rural areas of Assam especially around homestead ponds. This can be made climate-resilient especially against flood by bringing few changes in the prevailing practices, like sack cultivation of vegetable on pond dyke, floating cultivation of vegetable, etc. The non-conventional co-culture system may be introduced in pond aquaculture where small cage or pen can be installed in the pond to culture non-compatible species. Apart from these, for peri-urban areas, where there is the scarcity of land and water; intensive production systems like Recirculation Aquaculture System (RAS), Biofloc, in-pond raceways, etc. can be explored provided these systems are made suitable for culture of high value species and arrangements are made for marketing the live-fish to realise premium price.

2.2.8.3 Feed-based Aquaculture: In aquaculture, nutrionally balanced supplementary feed is crucial for the optimal fish growth and health, and thereby attaining the higher yield. In carp aquaculture, feed represents up to 60 % of the production costs. Though higher yield in feed-based aquaculture is a well-known fact, the practice is not yet popular in Assam. Many fish farmers of Assam use feed occasionally and that to use conventional mixture of oil cake and rice bran as the protein and carbohydrate sources. But the scenario is changing and the commercial fish feeds are gaining acceptance amongst the farmers. Commercial fish feeds are manufactured as either extruded (floating) or pressure-pellet (sinking) feeds. The use of balanced feed for fish is becoming increasingly popular among the commercial farmers for reaping better harvest. Therefore, sustenance and further expansion of the aquaculture activity in Assam will need promotion of concentrated feed production rather than relying on the conventional feed mixture.

While promoting establishment of feed mills, efforts should also be made to use locally available non-conventional feed ingredients.

2.2.8.4 Genetic Upgradation and Quality Seed Production: Over the years, Assam has attained self-sufficiency in fish seed production. At present there are more than 500 hatcheries in the state and most of them are under private sector. In the year 2019-20, the state has produced over 9000 million fish seeds. Scheme for hatchery accreditation and fish seed certification will go long way in maintaining the quality of seed in the state. For long term sustainability of aquaculture in Assam, genetic upgradation and breed improvement will be the key strategic areas. Development of improved strains of commercial species through selective breeding would be a priority in the coming decades. Hatchery operators in Assam should be sensitized about the ill effects of inbreeding (controlled breeding using same population over the years resulting in poor genetic base leading to retarded growth and low disease resistance). Therefore, replacement of parent fishes should be mandatory every two years. Jayanti rohu and Amur common carp developed through selective breeding have shown positive impact on fish production in Assam. Although multiple breeding and offseason breeding through controlled gonadal maturation in carps are successful in Assam during scientific trials, the same needs successful adoption by private hatcheries. Since Assam receives monsoon rain early, the fish seed should be available in the month of March-April for the fish farmers of Assam.

2.2.8.5 Health Management and Disease Surveillance: Health management plays a pivotal role in the sustainability of aquaculture. Increased occurrence of pathogens in the state will come as a consequence to the intensification process aquaculture activity. The misuse and drawbacks in antibiotics, problems of emerging pathogens, transboundary diseases, and poor quarantine etc. will further add up to these issues in the state. To meet the challenges of newer and emerging pathogens, there is a need to emphasize on the development of newer disease diagnostics. It is necessary to map the major diseases in freshwater aquaculture system of the state that are causing major economic loss to the sector. Targeted surveillance and health management practices should be taken up to control emerging diseases.

2.2.8.6 Invasive and Alien Species: While some of the species like *Pangasionodon hypophthalmus* have proven to be promising, many others like *Clarias gariepinus* have established in our natural waters and proven to be damaging our indigenous fish fauna. Therefore, before introduction of any of the exotics into the culture system of Assam, the risk assessment in terms of possibility of bringing danger to the indigenous fish fauna, study on their compatibility and quarantine measures to avoid the trans-boundary movement of various diseases and pathogens should

be ensured. Since Assam is heading towards multispecies farming; suitable policy framework should be put forth before introduction of any exotic species to reduce the risk.

2.2.8.7 Bio-safety and Bio-security: Aquaculture is becoming more and more plagued with disease problems resulting from its intensification and commercialization. The diseases are responsible towards 10-15% loss to the sector and it would rise further during the process of intensification. The movement of brood stock and fish seed, introduction of new species, expansion of the ornamental fish trade, poor or lack of effective biosecurity measures, lack of awareness on emerging diseases, etc. are the possible reasons for the same. The non-availability of farmer friendly diagnostics, active/passive surveillance system, vaccines and environment friendly chemotherapeutics would remain as major bottlenecks for the sustainability of the culture systems.

2.2.8.8 Gender Issues in Aquaculture: Aquaculture is widely recognised as a tool for empowering women. If women take up fish culture as a micro-enterprise it will lead to improved household nutrition, food security, better income and enhanced employment opportunity. In order to ensure that women utilize their full potential in aquaculture, it is necessary that they are linked with credit, technology, infrastructure, training and trade. These will ensure social and economic empowerment of women.

2.2.9 Beel Fisheries of Assam

As per the data of National Wetland Inventory and Assessment Project, Assam has total 3515 numbers of wetland (locally known as beel) having area of ≥ 2.5 ha. These wetlands cover a total area of 1012 km^2 (121200 ha.) which constitute 1.29% of the total geographical area of the state. They are mostly oxbow lakes, dead rivers, back swamps or tectonic depressions. These are mostly the floodplain wetlands associated with the rivers Brahmaputra and Barak. The predominance of floodplain wetlands in Brahmaputra basin is attributed to the often-changing course of rivers and their tributaries in the upper stretches. The river Brahmaputra passes through zones of acute seismic activity. Frequent earthquakes due to crustal instability induce local and sudden shifts in basement levels. This coupled with heavy discharge of water triggers the process of meander cut-offs leading to formation of oxbow lakes. Tectonic depressions are also formed due to earthquakes. Similarly, the Brahmaputra is prone to frequent and heavy floods, which break the levees leading to formation of back swamps. The wetlands are used for various purposes like economic benefit, livelihood security, sustainability, equity, conservation of biodiversity, maintenance of the ecosystem etc.

Beels of Assam are biologically rich and sensitive ecosystem that support unique aquatic biodiversity and play vital role in providing livelihood and nutritional security to a large section of the population of the state. Besides contributing to the environmental sustainability through carbon sequestration, flood plain wetlands also serve as source for harvesting flood and rain water. However, degradation and shrinkage of the floodplain wetlands have been recorded due to several natural and anthropogenic reasons. Conversion of wetland for human settlement and agricultural developments, road constructions, construction of bridge over the wetland and dam in the upstream of connected river, dumping of solid wastes, unsustainable levels of grazing and fishing activities will have economic and ecological losses in the long term. Primarily, the beels of Assam are under the control of the Revenue Department (Settlement). Since 1977, a substantial number of beels have been handed over to the Assam Fisheries Development Corporation (AFDC) for maintenance. The prime objective is to earn revenue for the State's exchequer. Historical information shows that the beels were once the common property of the community and conservation ethics were followed. Catching and killing of broodfish and juveniles were prohibited. Such conservation practices still prevail among the Tiwa community of the Morigaon district in central Assam (Baruah et al., 2000). Generally, the wetlands are considered as common property resources. The property rights are wide and vary from the highly controlled exclusive private properties to open access beels with almost no control. Various factors like size of the beel, traditional and customary rights, physiographic dimensions, accessibility and river connection etc. are the determining variables for the nature of property rights. The wetlands are managed for various objectives like economic benefit, livelihood security, sustainability, equity, conservation of biodiversity, maintenance of the ecosystem etc. In most of the beels, customary rights of the tribal and other indigenous ethnic groups are safeguarded legally (Phukan, 2006).

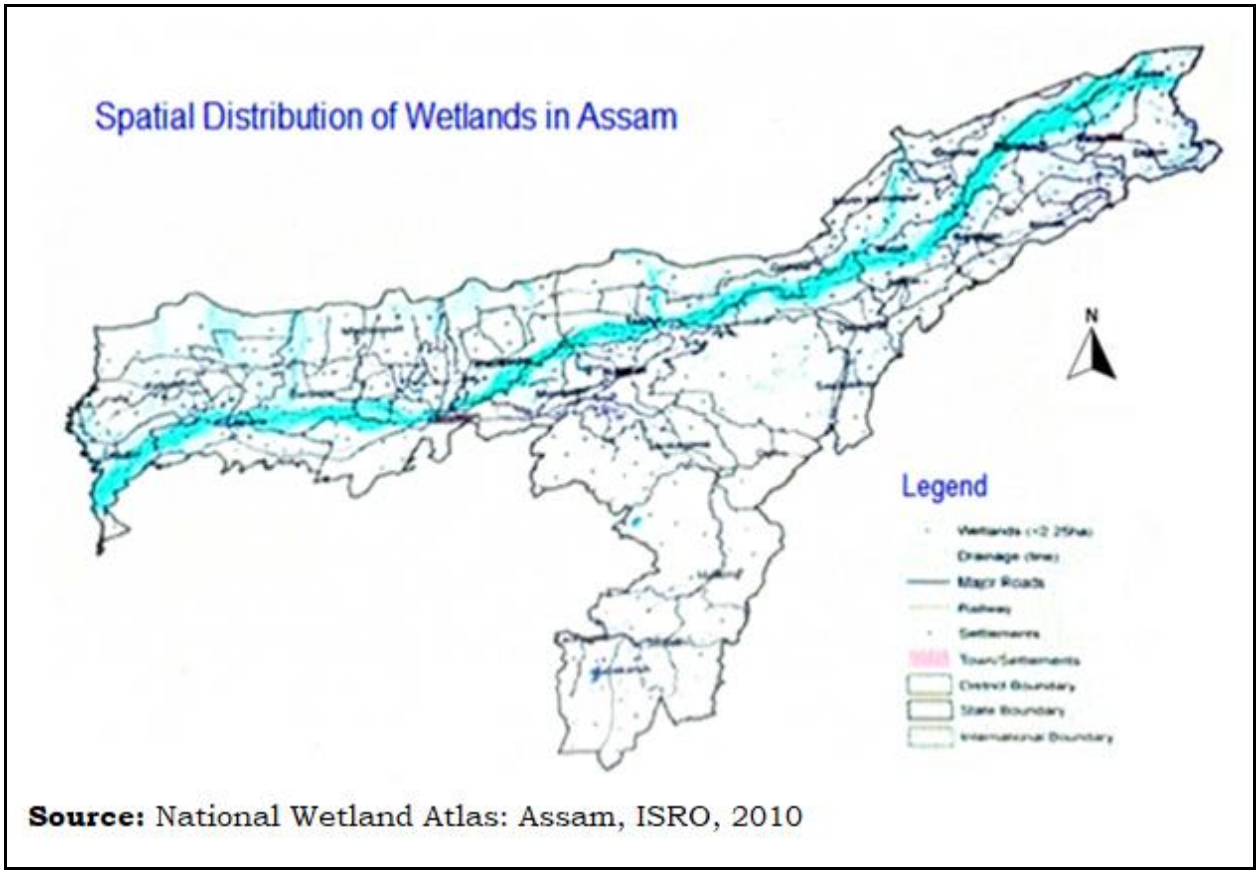


Figure 2.11 Spatial Distributions of Wetlands in Assam

2.2.9.1 Stakeholders associated with Beels of Assam

A large number of stakeholders, directly or indirectly, are associated with beels. Depending on the type and the nature of involvement, the stakeholders can be segregated into following categories.

Local user communities: Local user communities are the people who live in the vicinity and directly use the resources, and who, are partly in a subsistence relationship with the resources and partly in a market relationship i.e., the fishers, lessees.

Local communities having an indirect interest in the management of the resource: They are the people from local communities who rely on some function of the beels, such as flood control, but do not directly use the resources, e.g., villagers in adjoining areas.

Remote user communities: They are the people who come from a distance to use the resources and who may be in competition with the local users (or may have a long-standing arrangement with the local community), or may use a different component of the resources i.e., share fishers and labourers.

Commercial direct users of Beel resources: They are the individuals and groups who have purely commercial relationship with the resources i.e., lessees, middleman and fish traders.

Suppliers and marketers associated with *Beel* resource users: They belong to diverse group, including middlemen for wetland products, suppliers of inputs such as fuel and equipment, providers of credit, etc. This group can be extremely resistant to change in the status quo.

Government agencies with responsibility for management of some aspect of *Beel* resources: This might include a range of agencies with sectoral responsibilities for different resources, for example, Department of Fisheries, Assam Fisheries Development Corporation, Revenue Department, Panchayat, Department of Forest etc.

Supporters of *Beel* communities: They are the NGOs, development assistance organisations and concerned individuals who work in favour of the Beel dependent communities.

End consumers of *Beel* products: The beel products range from food staples, such as fish, rice to fuelwood, medicinal plants, stems and leaves for weaving, fodder for animals, etc.

2.2.9.2 Management of *Beels*

It is projected that the climate changes will have profound impact on wetlands, mediated through several direct and indirect pathways. Attention is urgently required at different levels for conservation and revamping of these resources along with coping up and mitigation strategies to address the impending challenges. Each of the stakeholders associated with beels operates at different levels of management. Therefore, a number of management domains exist with different components and output. However, among different stakeholders the fishers constitute the most important stakeholders as the life and livelihoods of them are dependent on the resources.

Table 2.14 Categorization of Wetlands of Assam based on Management Regimes

Attributes	Private Management	Fishers' Cooperative	Community based	Open Access
Management Right	▪ Managed by lessee (Individual or Group)	▪ Managed by fishers' cooperative societies	▪ Co-management approach ▪ Government agencies / NGOs involve communities in management & conservation	▪ No formal management
Legal Status	▪ Registered	▪ Registered	▪ Registered	▪ Unregistered
Access	▪ Controlled access (lessee and other fishers on paying some amount to the	▪ Controlled access (Members of the cooperative society)	▪ Controlled access by *Beel* Development Committee-BDC)	▪ Free access ▪ Almost no control ▪ Fishers operating in the *beel* are from adjoining locality or

	lessee or sharing the fish catch		▪ BDC is a group of individuals living in the adjacent village of a wetland coming together for effective utilization of the fisheries resources. ▪ The number of individuals in BDC depends upon the size of the *beel* and number of surrounding villages.	same community or tribes
Fishing Rights	▪ The lessee hires fishers to do the fishing. In most cases, fishers of adjacent villages are employed at low wages or on a share-harvest (often 60:40) basis.	▪ In some societies, the fish catch is pooled together and sold in the market and a part of income is shared among members of the communities. In other societies, fishers give one-fourth of their catch to the society as share of revenue.	▪ The *beel* development committee selects the executive committee for day-to-day operation of the fisheries.	▪ Locals have fishing rights ▪ Only capture fisheries are practiced in these *beels* based on the automatic recruitment during the flood period.
Lease Period	7 years	7 years	7 years	Not on lease
Other Privileges	▪ Wetlands are common property resources ▪ All traditional rights (except fishing) are integrated in property right	▪ All traditional rights (except fishing) are integrated in property right	▪ All traditional rights (except fishing) are integrated in property right	▪ customary rights of the tribal and other indigenous ethnic groups are safeguarded in these wetlands
Fisheries Improvement Activities	▪ Stock enhancement measures ▪ Seed stocking ▪ In-situ seed rearing in pen enclosures ▪ Weed control	▪ Stock enhancement measures ▪ Seed stocking ▪ In-situ seed rearing in pen enclosures ▪ Weed control	▪ Facilitate auto-stocking ▪ Seed stocking ▪ In-situ seed rearing in pen enclosures ▪ Weed control	▪ Only capture fisheries are practiced in these *beels* based on the automatic recruitment during the flood period.

	▪ Fishing by the lessee			

Table 2.15 Domain-wise Climate Resilient Strategies for *Beels* of Assam (modified from Chandra, 2009)

Domains of Management	Components	Outcomes	Climate resilient Strategies
Natural Process	▪ Nutrient assemblage ▪ Auto stocking ▪ Connectivity to River ▪ Biodiversity ▪ Flooding	▪ Productivity potential ▪ Techno-managerial options ▪ In-situ conservation ▪ Sustaining ecosystem	▪ Changes in hydrological features ▪ Strategies for sustainable productivity ▪ De-siltation of *Beels* ▪ Opening and widening of linkage channels
Human Intervention	▪ Management ▪ Fishing practices ▪ Efforts ▪ Weed control ▪ Bunds and spillways ▪ Katal or Zeng	▪ Sustainable production ▪ Productivity enhancement ▪ Resource use	▪ Adoption of Climate-resilient practices ▪ Promoting climate resilient native fish species ▪ Improvisation of fishing tools ▪ Judicious exploitation of Resources ▪ Creating provision of appropriate number of deep pools
Intervening Agencies	▪ Individuals ▪ Formal & informal groups ▪ Community ▪ Govt. Departments ▪ Traders & Commission agents ▪ Scientific organization ▪ Financial institutions	▪ Efficient resource use ▪ Increased participation ▪ Employment Generation ▪ Livelihood security ▪ Fishing ban & holidays ▪ Credit availability ▪ Technology adoption ▪ Resource monitoring	▪ Sensitizing stakeholders on Climate change issues ▪ Early warning system ▪ Prevention of anthropogenic stress
Institutional Linkage	▪ Institution Building ▪ Social Interaction & process	▪ Rules and Norms ▪ Information sharing and exchange ▪ Capacity utilisation	▪ Ecosystem/integrated approach for wetland management

	▪ Property relationship ▪ Social Institutions ▪ Market agencies	▪ Conflict resolution ▪ Increased participation ▪ Access to resources ▪ Community involvement	▪ Diversified livelihood options for indigenous fishermen
Policy Issues	▪ Leasing policy ▪ Infrastructure development ▪ Control of effort ▪ Resource Conservation ▪ Security mechanism	▪ Resource allocation, user right, user fees ▪ Sustainability ▪ Long term welfare ▪ Input support ▪ Improve decision making ▪ Endangered species Protection ▪ Participative and precautionary measures ▪ Improved enforcements ▪ Awareness ▪ Biodiversity conservation	▪ Community-driven development approach ▪ Promoting Enclosure/ pen culture ▪ Integration with other components ▪ Control of exotic species ▪ Restoration of degraded ecosystem

3 Climate Change Impact on Aquatic Food Production System of Assam

3 Climate Change Impact on Aquatic Food Production System of Assam

In the analysis of climate change pattern of Assam, the climatic phenomena like rise in temperature, change in precipitation, flood, drought, etc. become prominent and these are affecting the aquatic food production system (both culture and capture fisheries) of Assam the most. Fish being cold-blooded animal, its metabolic rate is strongly affected by environmental conditions, especially the temperature. The changes in temperature can have significant influence on the growth and reproductive biology of fish. The influence may be positive or negative depending on the circumstances. Extreme weather events like flood, drought can have serous negative impacts like crop loss due fish escape, mortality, etc. which will have adverse economic and social impacts on the dependent communities like fish farmers and fishers. In order to minimise the negative impacts, a range of actions can be taken / planned in the form of adaptation measures to climate change. Adaptation is the process of adjusting to change (both experienced and expected) with a long-term vision. The mitigation measure may be the other option which tends to lower or remove greenhouse gas emissions from atmosphere and thereby reducing the climate change naturally. Therefore, adaptation and mitigation are two sides of the same coin and must go hand in hand.

3.1 Assessing Vulnerability to Climate Change

The Intergovernmental Panel on Climate Change (IPCC) defines 'vulnerability' as 'the degree to which a system is susceptible to and unable to cope with adverse effects of climate change'. Vulnerability Assessment (VA) is very crucial in the climate change adaptation process. VA is a function of the sensitivity of a system to changes in climate (the degree to which a system will respond to a given change in climate, including beneficial and harmful effects), the degree of exposure of the system to climatic hazards, and adaptive capacity (the degree to which adjustments in practices, processes, or structures) can moderate or offset the potential for damage or take advantage of opportunities created by a given change in climate. The Aquatic food production system is gaining benefits in planning the adaptation strategies for the sector. In Aquatic food production system, it is linked to the changes in climate (either current or projected) with the ability of aquatic and human systems to cope with or benefit from such changes. In nutshell, VA help to target the adaptation actions by better understanding of the following:

- Who the vulnerable people/ community are and the production system/ species are and how their vulnerability can be reduced;
- Where the vulnerable ecosystems are and whether the targeted interventions can improve their capacity to adapt;

- Where the consequences of the vulnerability of aquatic food production system will be felt most and how it can be planned to minimize those consequences; and
- Whether the climate change scenario will bring new opportunities and accrue benefits and, importantly, for whom.

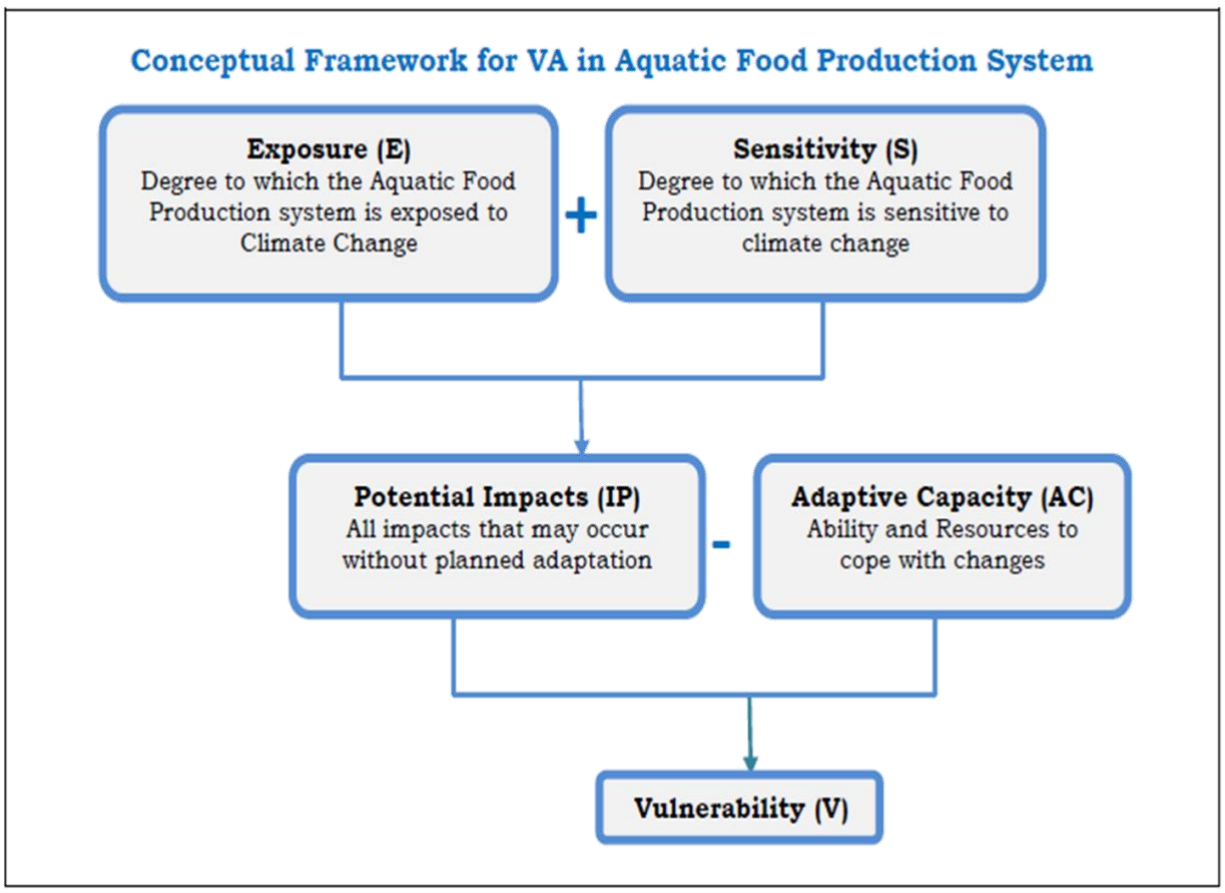


Figure 3.1 Conceptual Framework for Vulnerability Assessment in Aquatic Food Production System

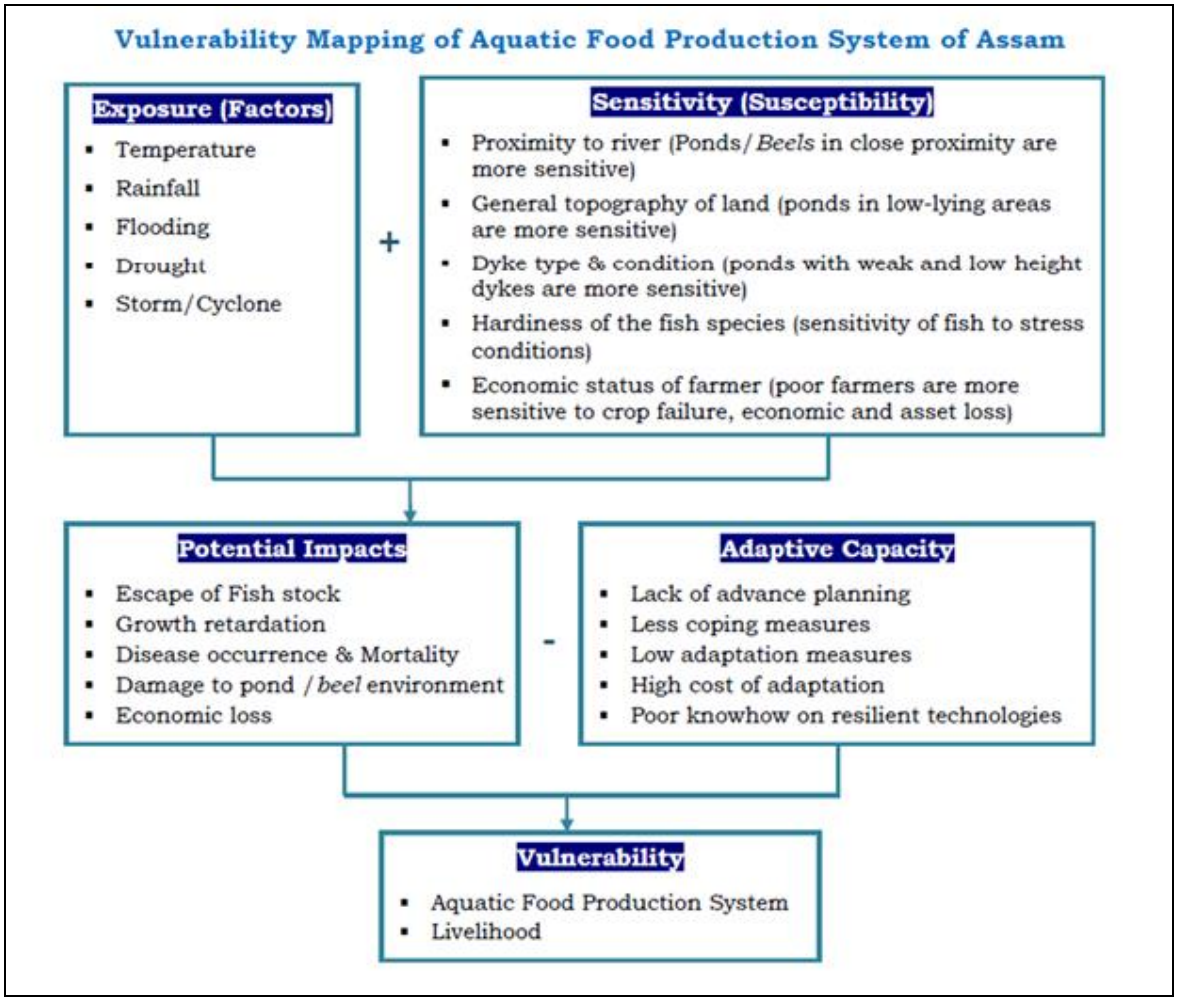


Figure 3.2 Vulnerability mapping of Aquatic Food Production System of Assam

Table 3.1 Overall Impacts of Climate Change on Aquatic Food production System of Assam

Drivers	Potential Impacts			Adaptation Options		
	Fish	**Production System**	**Stakeholder**	**Short-term**	**Medium-term**	**Long-term**
Warming (Warming of water)	▪ Increased metabolism ▪ Increased growth rate ▪ Advancement in the onset of breeding and longer breeding period for carps.	▪ Increased fish production ▪ Improved feed conversion efficiency for species with higher thermal tolerance ▪ Shift to shorter production cycle ▪ Intensified production	▪ Shorter production cycles leading to more income and higher profit	▪ Adjustment in farming Calendar ▪ Change/modification of farming practices ▪ Use of hide-outs in ponds to provide shade to fishes ▪ Weed refuge-based fishery in wetlands	▪ Creating Climate-smart facilities (*e.g.,* deeper ponds for aquaculture, deep pool-based fishery for wetlands, etc.)	▪ Farming of species /strains with higher thermal tolerance ▪ Risk-based Spatial planning for aquaculture ▪ Selective breeding to develop strain with wide thermal tolerance ▪ Culture of climate resilient fish species
	▪ Increased plankton respiration and proliferation ▪ Changes in reproduction ▪ Increased/ decreased transmission of some diseases	▪ Lower feed conversion efficiency for species subjected to increased stress ▪ Increased harmful algal blooms ▪ More risk on account of disease	▪ More feed required			
	▪ Decreased performance for species with narrow thermal range ▪ Increased sensitivity to other drivers like					

	low pH, pathogens					
Lowering of Dissolved Oxygen (Hypoxia)	▪ Increased mortality ▪ Reduced growth ▪ Higher sensitivity to some pathogens	▪ Lower carrying capacity of pond ▪ Increased aeration costs ▪ Reduction in the number of annual crops where hypoxia is seasonal	▪ Increased aeration costs ▪ Farmers culturing hardy species like tilapia, pangasius, etc. not affected	▪ Reduction in biomass / stocking density ▪ Pumping of aerated water into pond	▪ Making provision for aeration ▪ Increased monitoring of water quality	▪ Shifting to more tolerant (hardy) farmed species or strains
Changes in other Hydro-graphic variables	▪ Increased mortality ▪ Reduced growth	▪ Poor water quality ▪ Accumulation of wastes	▪ Changes in production levels	▪ Liming at regular interval in ponds	▪ Bottom drying and desilting for ponds ▪ Provision for bore well in farm	▪ Spatial planning for favourable areas to do aquaculture ▪ Restoring riverine connectivity in wetlands
Flood	▪ Escape of fish stock from pond ▪ Entry of unwanted fishes ▪ Growth retardation of fishes ▪ Increased mortality	▪ Breach of pond dyke ▪ Ingression of flood water into pond ▪ Increased risk of fish escapes as a result of flooding, overspills ▪ Deterioration of water quality	▪ Loss in production ▪ Facility destruction ▪ Economic loss	▪ Net fencing along the pond dyke ▪ Effective dyke management and intercropping in dyke ▪ Sack cultivation of vegetable on pond dyke ▪ Mechanisms for Flood Early Warning System to farmers and fishers	▪ Short duration fish farming ▪ Introduction of scheme for fish crop insurance ▪ Preparation of flood contingency plan by Fishery Dept., GoA	▪ Investing in stronger flood protection facilities ▪ Relocating farms in less prone areas

Drought / water stress situation	▪ Mortality ▪ Reduced growth ▪ High physiological stress	▪ Less water ▪ Early drying of pond and wetlands in summer ▪ Poor water quality ▪ Eutrophication of pond and wetlands ▪ Reduced production efficiency	▪ Loss or disruption of Livelihoods ▪ Increased competition for water ▪ Economic loss	▪ Shift to shorter production cycles ▪ Promoting Hotel size fish production ▪ weed refuge-based fishery in wetlands	▪ More deep ponds ▪ Deep pool-based fishery in wetlands	▪ Shift to indoor facilities like Recirculating Aquaculture Systems (RAS), Biofloc, etc. ▪ Invest in water efficient technologies
Depletion of ground water leading to water stress condition	▪ High physiological stress ▪ Reduced growth ▪ Mortality	▪ More risk for ground water dependent production system ▪ Reduced production efficiency ▪ Poor water quality	▪ Higher costs of maintaining pond water levels ▪ Poor production ▪ Economic loss	▪ Arranging alternative water source to reduce dependency on ground water	▪ Focusing on efficient surface-water irrigation infrastructure	▪ Demand-side management by restricting excessive withdrawal of groundwater ▪ Supply-side management by adopting recharge enhancement measures
High intensity weather event (heavy rain, storm, etc.)	▪ Increased mortality ▪ Escape of fish stock & entry of unwanted species	▪ Disruption in supply of inputs such as Seed, feed etc. ▪ Pollution by heavy runoff	▪ Increased work hazards ▪ Economic loss	▪ Taking emergency measures to prevent escape of stock ▪ Relief for affected stakeholders	▪ Preparation of contingency plan for natural calamities by Fishery Dept., GoA	▪ Relocating farms in less prone areas
Less predictable rainy/dry season	▪ Impacting fish mating and spawning behaviour	▪ Affecting the hatchery operations ▪ Loss in breeding opportunity	▪ Decreased ability to plan the work ▪ Economic loss	▪ Increased monitoring of weather variables	▪ Agro-meteorology advisories	▪ Developing weather-controlled facilities
Climatic hazards	▪ May get contaminated	▪ Overflowing of untreated sewage during flood	▪ Health hazards ▪ Economic loss	▪ Emergency preparedness	▪ Adoption of best practices in	▪ Enhancing bio-security practices

causing food safety issues	with heavy metals and pesticides, infected with food borne parasites and pathogens	▪ Increasing run-off of fertilizers, topsoil, as well as pollutants, such as pesticides, herbicides, trace metals and persistent organic pollutants		▪ Early warning ▪ Risk mitigation strategy	production and post-harvest operations	▪ Implementing hazard-specific food safety measures
Knowledge Gaps in resilient practices	▪ The impact may differ depending upon the spectrum of tolerances of cultured species	▪ Farm facilities are not in sync with adaptation requirements	▪ Farmers make ill-informed aquaculture choices ▪ Higher cost of adaptation if maladaptation options are chosen first	▪ Strengthening Early warning systems and better monitoring ▪ Emphasis on diversified production system ▪ Selecting species with wide spectrum of tolerance	▪ Modified insurance schemes ▪ Social protection strategies	▪ Focus on research to fill the gaps and reduce uncertainties ▪ Selective breeding to develop strains with high thermal tolerance

Colour Legends Overall Favourable Impact (light Green) | Both Positive and Negative Impact (light Blue) | Overall Unfavourable Impact (light Red) | No Foreseen Impact (light Grey)

Table 3.2 Vulnerability of Culture Fishery to Climate Change in Assam

Threat	Description of Threat	Likeli-hood	Conse-quence	Impact Level	Impact Summary	Adaptive Capacity	Vulnera-bility
Increase in temperature	Increase in mean ambient temp., rise in maximum temp. in all seasons - summer, winter and wet season; hotter and long summer, short winter; higher changes in	High	Medium	Medium	Reduced oxygen levels, poor water quality, physiological stress on fish, high disease incidence, reduced survival rate of fish, etc.	Medium	Medium

	minimum temp.; irregularities in season change						
Increase in precipitation	Increase in heavy rainfall events; erratic rainfall with unpredictable and out-of-season rain, more pre-monsoon and post-monsoon rain	Medium	Low	Medium	Reduced water quality due to turbidity, greater fluctuation in p^H and oxygen levels, reduced productivity of pond and poor growth of fish	High	Low
Decrease in precipitation	Overall decrease in low and medium rainfall events; intermittent dry spells in the middle of monsoon season	Medium	High	High	Stagnation of pond water, Ammonia accumulation, changes in breeding periodicity of auto-recruiting species, deterioration of water quality, Fish mortality	Low	High
Reduced in water availability in peak summer	Decreased annual rainfall, reduced water availability from the sources like ground water, near-by river or stream, early drying of pond in summer	Medium	Medium	Medium	Accumulation of wastes in pond; Poorer water quality; difficulties in maintaining water level in ponds; Reduced survival and poor growth of stock	Low	Medium
Drought	Drought-like situation occurs due to prolonged dry spell without rain, creates water stress environment	Medium	Very high	High	Drastic reduction of pond water levels, poorer water quality, fish mortality, negative effects are compounded by temperature increase	Low	High
Flood	Increase in frequency and intensity of flood, extent and duration of flooding varies, sometimes flash floods aggravate the problem	High	Very high	Very high	Breach of pond dyke and other structural damage, ingression of flood water into pond, escape of fish stock from pond, entry of predatory fishes in pond, invasion of exotic species, damage to pond environment, reduced production	Very Low	Very High
Lowering of ground water level	Reduced water output from bore wells due to high levels of groundwater extraction, less rain and poor rainwater recharge, huge threat for bore-well dependent ponds, early drying of pond in summer	Low	High	Medium	Reduction of pond water level, poor water quality, fish mortality, negative effects are compounded by temperature increase	Low	Medium

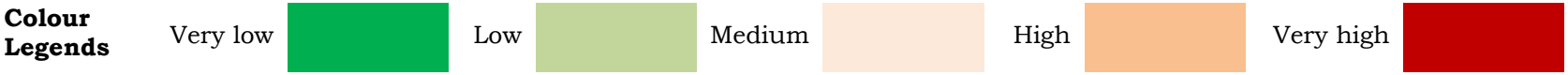
Colour Legends Very low | Low | Medium | High | Very high

Table 3.3 Vulnerability of Capture (*Beel*) Fishery to Climate Change in Assam

Threat	Description of Threat	Likeli-hood	Conse-quence	Impact Level	Impact Summary	Adaptive Capacity	Vulnera-bility
Increase in temperature	Increase in mean ambient temp., rise in maximum temperatures in all seasons - summer, winter and wet season; hotter and long summer, short winter; higher changes in minimum temp.; irregularities in season change	High	Low	Medium	Reduced water quality, depleted dissolve oxygen, increased stratification, etc. All these lead to reduction of primary productivity, degradation of wetland ecosystem and affecting overall fishery	Low	Medium
Increase in precipitation	Increase in heavy rainfall events; erratic rainfall with unpredictable and out-of-season rain, more pre-monsoon and post-monsoon rain, etc.	Medium	Medium	Medium	Reduced water quality due to turbidity, greater fluctuation in overall water quality parameters, reduced productivity of wetland	Medium	Low
Decrease in precipitation	Overall decrease in low and medium rainfall events; intermittent dry spells in the middle of monsoon season	Medium	High	High	Stagnation of water, water column stratification, changes in breeding periodicity of auto-recruiting fish species, deterioration of water quality, etc.	Low	High
Drought	Drought-like situation occurs due to prolonged dry spell without rain, creates water stress environment	Medium	Very high	High	Shrinkage of water spread area, reduction in water level, poorer water quality, fish mortality, competition with other water users	Low	High
Flood	Increase in frequency and intensity of flood, extent and duration of flooding varies, sometimes flash floods aggravate the problem	High	Medium	Medium	Ingression of flood water into wetland, damage to facilities, escape of fish stock from wetland, entry of predatory and other fishes into wetland leading to economic loss, invasion of exotic species, etc.	Low	Medium

Aquatic weed Proliferation	Elevated temp., warmer winter, prolonged summer, etc. result in longer persistence of concentrated nutrients in limited volumes of water leading to eutrophication. High intensity weather events like storm and flood bringing in plants, seeds and spores of aquatic weeds	Medium	High	Medium	Disruption in natural food-chain and depletion of fish stocks. Fishers face with the dwindling fish stock to catch upon, resulting in the loss of their livelihood. The situation may leads to their migration as labourers to other sectors for economic sustenance.	Medium	Medium
Sedimentation and loss of Connectivity with river	Influx and deposition of sediments during monsoon, sediments often get trapped by heavy mass of weeds, repeated flooding and drying up	Medium	Low	Medium	Degeneration of wetland ecosystem, failure in natural fish seed recruitment into wetland, loss of fishery	High	Low
Periodic recruitment failure of Small Indigenous Fish Species	Delayed arrival of monsoon rains, absence of pre-monsoon rains, flash floods resulting in smothering of fish eggs with silt/mud	Low	Medium	Low	Loss in biodiversity and altered composition of fish species, dwindling stock of Small Indigenous fish species	Medium	low
Increased Agricultural pesticide run-offs	Flash floods resulting from low-duration high-intensity rains accumulate active ingredients of agricultural pesticides in wetland	Medium	Low	Low	In dry months, the residual pesticides get concentrated and affect the survival and growth of fish. In extreme case, it may also kill fish	Low	Medium
Rampant encroachment of wetland (non-climatic factor)	High economic demand of land for real estate, construction of road, agriculture, etc. have accelerated the encroachment of wetlands	Very High	High	High	Wetlands get filled-up, and polluted, shrinkage of area, closure of riverine connection, disruption in natural fish seed recruitment into wetlands, etc.	Medium	High
Miscellaneous anthropogenic stressors (non-climatic factor)	Overexploitation of fish stock, wanton killing of brooders and juveniles, etc.	Medium	High	Medium	Stock collapse due to heavy exploitation pressure and climate-related stresses, decline in indigenous fish species, etc.	Medium	Medium

Colour Legends



4 Analysis of Survey Data & Results

4. Field Data Analysis & Results

The primary data were collected from field through questionnaires-based interviews, focus group discussions and PRA. However, the number was kept low due to time constraint as well as on account of ongoing COVID-19 pandemic. The collected data were entered in MS Office excel software and reports were generated pertaining to relevant aspects of fisheries and aquaculture and the impact of climate change on fisheries and aquaculture. Summarized data are presented both in tabular and graphical forms. Inferences are drawn after thorough analysis of data and are presented below.

4.1 KAP Survey

Knowledge-Attitude-Practice (KAP) survey was conducted in six districts, namely Barpeta, Nalbari, Nagaon, Darrang, Jorhat and Cachar comprising of total 60 fish farmers, 10 farmers randomly selected from each selected district. A cross-sectional multi-layered interview-based questionnaire was purposively developed covering all types of aquafarming situations of Assam.

4.1.1 Socioeconomic Profile of Fish Farmers: Socio-economic Profile of the surveyed aqua farmers is presented as table 4.1 and figure 4.1. Among the respondents, 90% are male and only 10% are female. Amongst Hindu, 38.33% respondents belong to general category, followed by 35% from OBC category, and 10% from SC category. The 16.67% respondents belong to Muslim community. Majority of respondents (93.33%) are of the age group of 30-50 years as this age group is actively involved in fish farming. 51.67% of the respondents are from the small-scale farmer category with farm size of 1-5 *bigha* (0.13-0.65 ha.) and the rest are medium scale farmer. Majority of farmers are literate (88.33%). Though aquaculture is an age-old practice in Assam, scientific farming method is relatively new to the farmers. This is possible due to dissemination of modern technologies among the farmers through training and demonstration. During the survey it is found that 75% of farmers received knowledge on scientific fish farming through training programmes which are sponsored by Government agencies and NGOs.

Table 4.1 Socio-economic Profile of the surveyed aqua farmers (n= 60)

Variable	Description	Response (%)	Variable	Description	Response (%)
Religion & Caste	General	38.33	Nature of Holding	Own	65.00
	OBC	35.00		Multiple owners	3.33
	SC	10.00		Leased pond	31.67
	Muslim	16.67	Educational Qualification	Illiterate	11.67
				Literate	88.33
Gender	Male	90.00	Knowledge source in farming	Govt. training	51.67
	Female	10.00		NGO training	23.33
Age	< 30 yrs	1.67		Other farmer	23.33
	30-50 yrs	93.33		Self-taught	26.67
	> 50 yrs	5.00		Mass media	0.00
Farm size	< 1 *Bigha*	0.00			
	1-5 *Bigha*	51.67			
	> 5 *Bigha*	48.33			

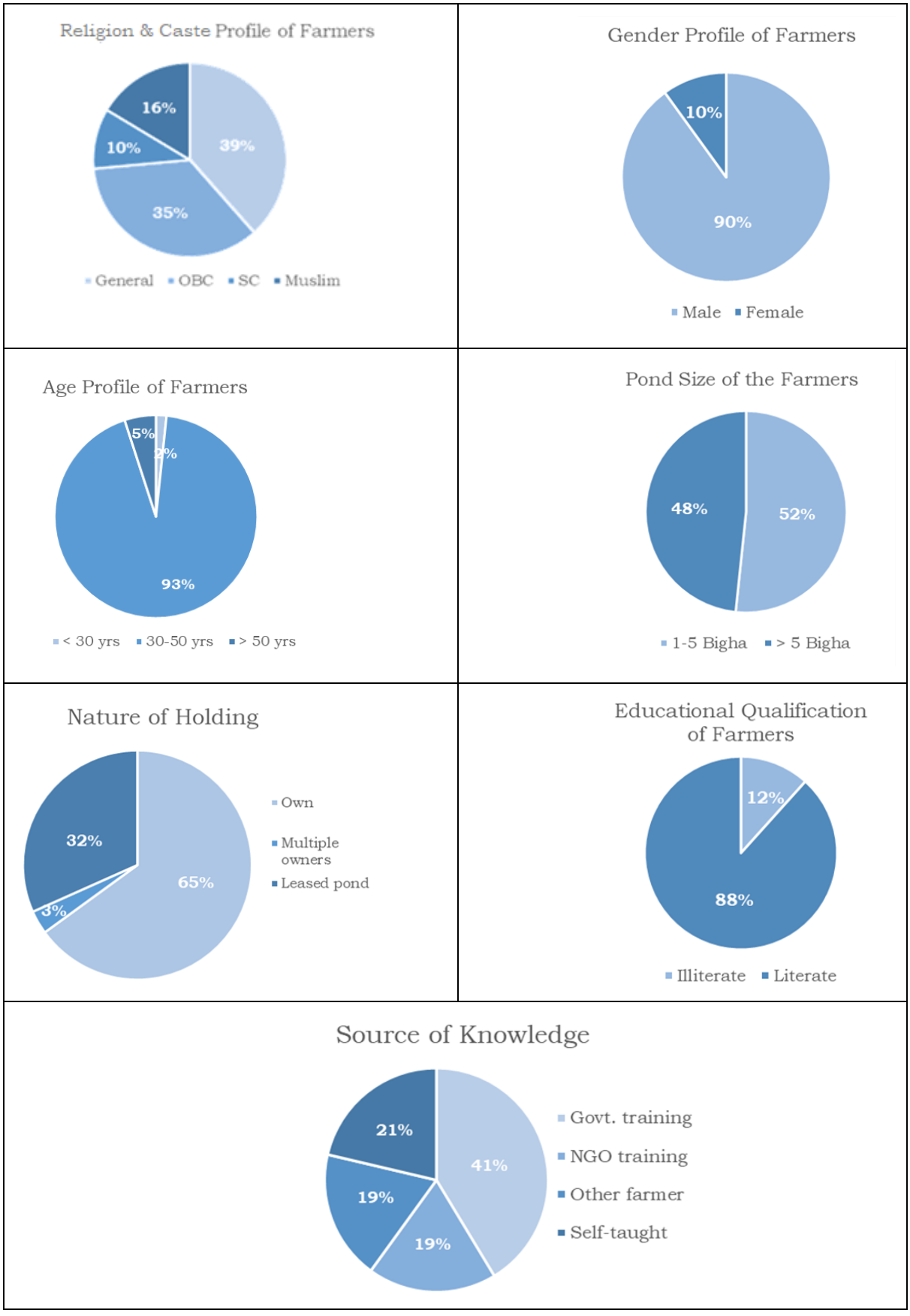


Figure 4.1 Socio-Economic Profile of the Farmers (% of respondents)

4.1.2 Prevailing Aquaculture Practices: The prevailing aquaculture practices are as given in table 4.2 and figure 4.2. Majority of surveyed ponds are perennial (95%), thus suitable for year-round aquaculture. Among the respondents, 58.33% farmers are found to practise fish culture alone, whereas 41.67% farmers culture fish with livestock like pig, duck, poultry, etc. with integrated approach. This indicates the popularity of livestock-fish integration in Assam as compared to others major states of India. 53.33% of farmers practise extensive farming with moderate production level, while of 36.67% farmers practise semi-intensive farming with high production level. Only 10% farmers follow traditional farming. Farmers invariably used hatchery produced carp seed as stocking material in farming indicating that over the years farmers of Assam have totally switched over from wild caught seed to hatchery produced seed. This is a healthy sign as no sustainable commercial aquaculture practice can depend on seed from natural source. 76.67% farmers acclimatize the seed at the time of stocking in the pond indicating that majority of farmers follow scientific culture practices. More farmers (68.33%) practice single stocking in carp polyculture and presence of self-recruiting species like *mola* in carp ponds is very common (91.67%). The survey revealed that ponds are not used for other domestic purposes like bathing, house chores etc. All farmers use supplementary feed in different forms like rice barn and oilcake (53.33%), branded feed (20.00%) and farm made feed (26.67%). The farmers expressed different views regarding peak season of disease occurrence in fish. 53.33% farmers reported winter season as peak season of disease occurrence in fish, while 30% farmers reported summer season for that. This indicates that from winter season onwards when water depth in ponds reduces; water quality deteriorates leading to occurrence of more diseases. Further investigation revealed that the infestation of parasites like Argulus in fish is common (65.00%), followed by body ulcer (epizootic ulcerative syndrome-EUS) (23.33%) and fin & tail rot (11.67%). For treatment of disease, farmers mostly use lime (56.67%) and other chemicals (31.67%) and occasionally use antibiotics (8.33%). Good number of farmers (70.00%) adopt some kind of bio-security measures like seed disinfection before stocking, net covering over pond to scare predatory birds, etc. for their ponds. 58.33% farmers reported fish production of more than 3000 kg/ha/yr Very few farmers (3.33%) reported poor yield (<2000kg/ha/yr.). Most of the farmers (68.33%) sell the harvested fish in local market, while some (26.67%) hand over to the middleman and very few are able to dispose at pond site.

Table 4.2 Aquaculture practices of the surveyed farmers in Assam (n= 60)

Variable	Description	Response (%)	Variable	Description	Response (%)
Pond Type	Seasonal	5.00	Type of feed	Rice bran & oilcake	53.33
	Perennial	95.00		Branded Feed	20.00
Farming Type	Traditional	10.00		Farm made	26.67
	Extensive	53.33	Common diseases	Parasites/Argulus	65.00
	Semi-intensive	36.67		Body Ulcer (EUS)	23.33
Farming Principle / integration				Fin & tail rot	11.67
	Polyculture	58.33			
	Integrated	41.67	Peak season of disease	Summer	30.00
				Monsoon	16.67
Seed Source	Hatchery	100.00		Winter	53.33
	Wild collected	0.00	Treatment against disease	Liming	56.67
Seed acclimatization	Yes	76.67		use of chemicals	31.67
	No	23.33		antibiotics	8.33
Stocking type	Single	68.33		water exchange	3.33
	Multiple	31.67			
Self Recruiting Species	Yes	91.67	Biosecurity measures	Yes	70.00
	No	8.33		No	30.00
Other than aquaculture use of pond	Bathing	0.00	Fish production (kg/ha/yr.)	< 2000 kg	3.33
	House chores	0.00		2000-3000 kg	38.33
	Livestock bath	73.33		>3000 kg	58.33
	No other use	26.67	Mode of Fish marketing	At pond site	5.00
Supplementary Feed	Yes	100.00		Middleman	26.67
	No	0.00		Local market	68.33

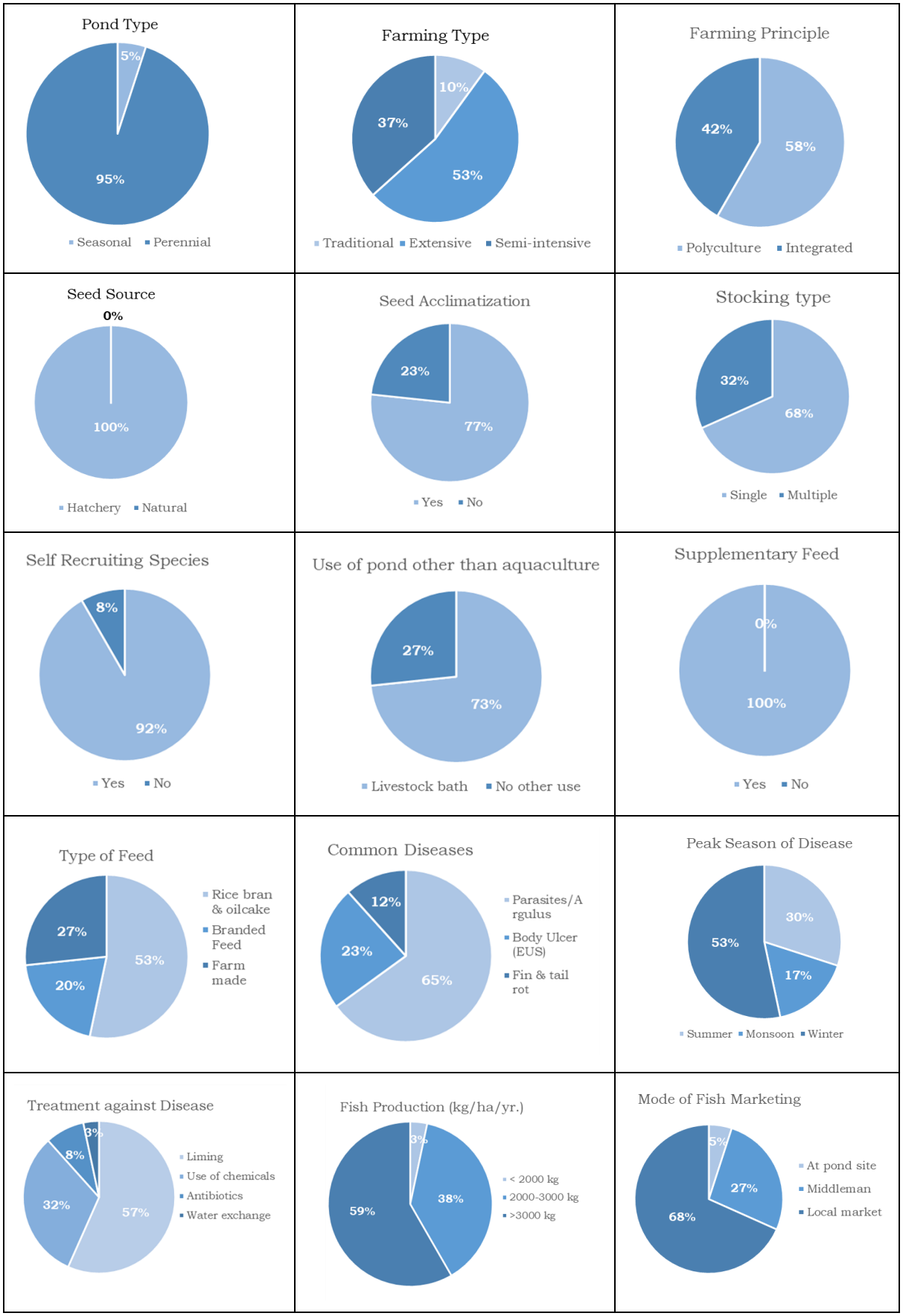


Figure 4.2 Aquaculture practices of the Farmers (% of respondents)

4.1.3 Farmers' Perceptions on Climate Change: All fish farmers included in this survey are aware of climatic variability (table 4.3 and figure 4.3). Respondents expressed their personal experiences of changes in climate in terms of temperature, rainfall, and flood. 75% of the respondents expressed rise in temperature. The respondents further explained the observed changes in temperature in many ways, of which the most commonly experienced changes are irregularities in season (88.33%), hotter summer (45%) and long summer (21.67%). A small fraction (16.67%) of respondents stated drought as the observed changes in temperature due to the less predictable nature of temperature and rainfall. Majority of respondents (71.67%) observed the rise in rainfall over the years. The erratic nature of the monsoon was also reported by the farmers. Many farmers expressed their concern about heavy rainfall during onset and offset of monsoon (61.67%) and erratic monsoon (53.33%). Heavy inundation and prolonged flooding are reported by many farmers (65%) and are characterized by increase in intensity (45.00%) and increased frequency (33.33%).

Table 4.3 Aqua-Farmers' perceptions on climate change events in Assam (n= 60)

Climatic Variables	General perceptions		Observed Impacts	
	Local Experience over 20-30 yrs.	Respon-se (%)#	Indicators ^	Respon-se (%)#
Temperature	Increased	75.00	Irregularities in season change	88.33
	Decreased	8.33	Hotter Summer	45.00
	Unchanged	16.67	Long Summer	21.67
			Drought	16.67
			Short winter	5.00
Rainfall	Increased	71.67	Heavy rainfall during onset & offset of monsoon	61.67
	Decreased	25.00	Erratic Monsoon	53.33
	Unchanged	1.67	Shortening of Monsoon	30.00
			Lingering of Monsoon	26.67
			High Rainfall	8.33
			Low Rainfall	6.67
Flood	Increased	65.00	Increased in intensity	45.00
	Decreased	23.33	Increased frequency	33.33
	Unchanged	11.67	Decreased frequency	30.00
			Decreased intensity	5.00

^ Indicators are arranged on the order of rank, # Respondents exercised more than one option

Figure 4.3 Aqua-Farmers' perceptions on climate change patterns in Assam

4.1.4 Impacts of Climate Induced Events on Aquaculture: In the context of Assam, the climate induced events like flood and drought adversely affect the aquaculture operation. In the study, the adverse impact was evaluated using the risk rating matrix as an assessment tool. The risk was analysed in detail using colour codes (table 4.4) by considering the likelihood of ponds being affected as a result of the event and the varying degrees of consequences thereof. Ponds in the proximity of rivers and periphery of the embankments often experience great damage. During the survey, farmers opined that when floods affect an area, aquaculture ponds are inundated. This results in existing fish stocks to escape into the floodplains. Preventing the escape of cultured species is very difficult during sudden or prolonged floods. Floods allow the entry of predatory and other unwanted fishes which in turn hamper the natural assemblage of the culture system. Growth retardation and altered feeding habits of the surviving fish are also noticed by some farmers after flooding events as a result of stress. Farmers reported that due to flooding, a huge volume of debris, dead organisms, toxic substances and land-based pollutants such as plastics have accumulated in the ponds and adversely affected the pond ecosystem. In addition, the water quality of the ponds sharply deteriorated after floods because of the decomposition of dead organisms, plant debris etc. that lowered the pH of the water leading to deterioration of the overall water quality and outbreak of disease. This had often detrimental effects on the survival, growth, feeding and production of fishes.

Table 4.4 Views of the farmers on impacts of climate induced events like flood, drought etc. on aquacultures (n= 60)

Impacts	Likelihood (%)					Consequence (%)				
	Very unlikely	Unlikely	Fairly likely	Likely	Very likely	Insigni-ficant	Minor	Moderate	Major	Catas-trophic
Breach of pond dyke	0	0	1.7	8.3	90	0	0	5	35	60
Ingression of flood water	0	3.3	5	60	31.7	0	1.7	8.3	38.3	51.7
Escape of fish stock from pond	0	1.7	10	41.7	46.7	0	0	10	36.7	53.3
Mortality of fishes	0	0	10	41.7	48.3	0	0	6.7	46.7	46.7
Entry of unwanted fishes	0	0	13.3	35	51.7	0	0	8.3	36.7	55
Growth retardation in Fish	0	0	20	31.7	48.3	0	0	13.3	38.3	48.3
Damage to pond environment	0	1.7	8.3	36.7	53.3	0	3.3	16.7	35	45
Deterioration of water quality	0	1.7	10	45	43.3	0	1.7	6.7	46.7	45
Rise in disease outbreak	0	1.7	5	45	48.3	0	0	13.3	40	46.7
Early drying of pond in summer	0	6.7	18.3	20	55	1.7	11.7	13.3	21.7	51.7
Changes in breeding periodicity	0	3.3	8.3	30	58.3	0	5	8.3	33.3	53.3
Water scarcity	0	5	8.3	31.7	55	0	5	6.7	28.3	60

Likelihood Colour Scale: 0 % → → → → → → → → → → → → → → → → → → 100 %

Consequence Colour Scale: 0 % → → → → → → → → → → → → → → → → → → 100 %

4.1.5 Coping Measures Adopted by Farmers: Among the surveyed farmers, many are affected by the flood. To get relief and to minimize the loss, they invariably adopt various coping measures as listed in the table below. A number of farmers (63.33%) take up repair or re-construction the pond dykes that would make them higher, stronger and wider. In order to make dykes more stable, 68.33% of the respondents plant various types of trees on the pond dykes. Also, many farmers (55%) erect net fencing around the pond in order to prevent fish escaping as well as to avoid the entry of predator fish during inundation by flood waters. To improve pond water quality and prevent further disease outbreaks after flooding, almost all farmers (93.33%) apply lime and disinfectants. The survey results indicated that the respondents are aware of and concerned about the unpredictable climatic conditions, but their vulnerable financial condition and lack of preparedness sometime restrict their ability to adopt the coping measures.

Table 4.5 Coping measures adopted by the farmers (n= 60)

Coping Measures Adopted	Response (%)#
Application of lime / disinfectants	93.33
Plantations on pond dyke	68.33
Increase of pond dyke height	63.33
Erecting net fencing around the pond	55
Harvesting the crop before flood	23.33
Pumping out the flood water	3.33
Pumping out of polluted water & addition of freshwater	3.33

#Respondents exercised more than one options

4.2 KII Survey

KII survey gathered individual-level data and opinions on climate change and its impact on aquatic food production system of Assam, from the local experts like researchers, academicians, Govt. officials, etc. During the study, the information and insights on following key areas were collected through KII.

- Perceptions on Climate Change
- Impact of Climate Change on Seed Production, Fish Culture & Capture Fishery
- Coping Measures for Seed Production, Fish Culture & Capture Fishery
- Adaptation Strategy for Fish Culture & Capture Fishery
- Climate Change Impact on Fish Value Chain
- Climate Smart Investment Opportunity in Fisheries

The experts offered their level of agreement/disagreement to five key statements (A to E) on climate change adaptation (table 4.6 and figure 4.4) Majority of the respondents (80%) strongly agreed to the statement-C that says, it is necessary to have climate resilient strategies that both support general development and climate adaptation in the vulnerable region. The pertinent statements were put before the experts to answer them using agree and disagree scale. The answer to the statements varied from strongly agree to disagree. None of the respondents strongly disagreed to any statement.

Table 4.6 Level of Agreement/Disagreement to the statements by experts (n=20)

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
A) The general understanding of the implications of climate change is improving. However, information on local-level impacts and vulnerabilities is lacking, which hampers adaptation planning.	35%	65%	0%	0%	0%
B) Climate smart adaptation needs to take place at all levels (individual, business, community, national and regional) and time scales. All stakeholders from private and public sectors should be involved in developing context-specific options.	60%	40%	0%	0%	0%
C) Considering the uncertainties of the climate change, it is necessary to have climate resilient strategies that both support general development and climate adaptation in the vulnerable region.	80%	20%	0%	0%	0%
D) Climate change crisis may bring some new opportunities in fisheries sector. This will create climate-smart business opportunities for development in the sector.	30%	65%	5%	0%	0%
E) The climate change impacts in aquatic food production system affect the nutrition security, consumer prices and supply-demand gaps. Therefore, the implications of climate change on the entire supply and value chain need to be better understood.	35%	55%	5%	5%	0%

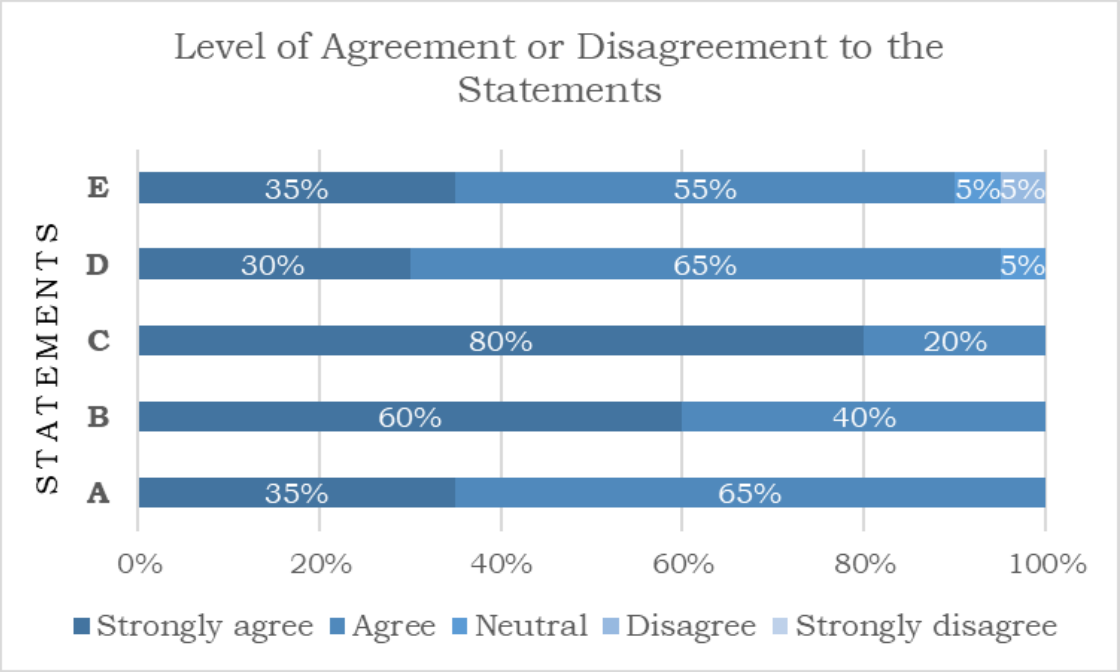


Figure 4.4 Level of Agreement/Disagreement to the statements by Experts

The climate-smart aquatic food production system is generally guided by two basic goals: (i) increased productivity (sustainably intensifying production) through enhanced resilience (adapting to climate change), (ii) reduced emissions (mitigating greenhouse gas emissions). Reduced emissions may be considered as secondary goal, while the primary goal should be the enhanced resilience leading to increased productivity. In KII survey, the experts were requested to propose some climate-smart interventions for enhanced resilience in aquatic food production system in Assam. All experts recommended short-term fish culture and stocking of advanced fingerlings as climate-smart interventions for the farmers (table 4.7 and figure 4.5). Many experts suggested activities such as stocking of self-recruiting species like *Mola*, adoption of BMP, overwintering of fish seed, effective dyke management and intercropping in dyke, adoption of biosecurity measures, deep-water rice-fish integration, floating cultivation of vegetable in wetland, application of low-cost organic manure, periphyton based food production, sack cultivation of vegetable on pond dyke as climate-smart interventions.

Table 4.7 Climate-Smart Interventions proposed by Experts for Small-scale Aquaculture (n= 20)

Climate Smart Interventions	Response (%)#
Short-term fish culture	100
Stocking of advanced fingerlings	100
Stocking of self-recruiting species / SIS like *Mola* etc.	95

Adoption of BMP	90
Overwintering of fish seed	80
Effective dyke management and intercropping in dyke	80
Adoption of biosecurity	65
Deep-water Rice-fish integration	65
Floating cultivation of vegetable in wetland	60
Application of low-cost organic manure	55
Periphyton based food production	50
Sack cultivation of vegetable on pond dyke	45

Respondents exercised more than one options

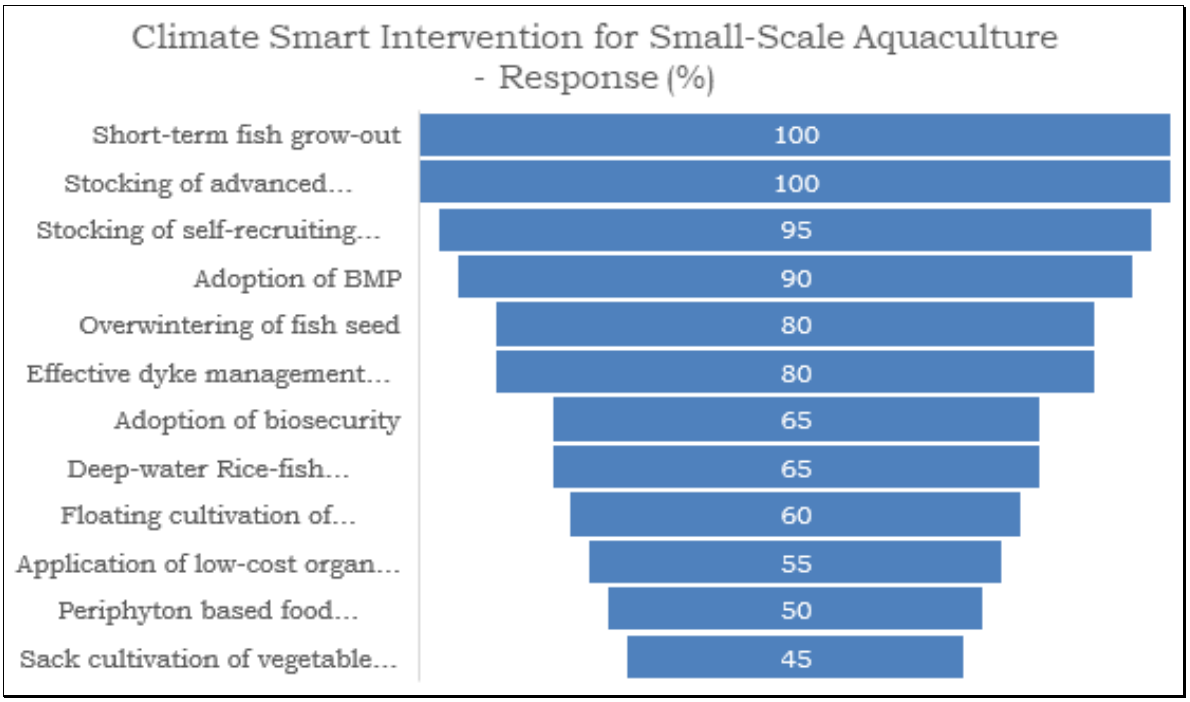


Figure 4.5 Climate-Smart Interventions proposed by Experts for Small-scale Aquaculture

Coping measures typically involve conscious, on-the-spot and direct approach which farmers take to tackle the problems. These are often short-term measures and considered as potent way to solve the problems and to minimize the immediate loss. On the contrary, adaptation measures involve rational and scientific approach to the problems and these are often long-term measures. In KII survey, the experts offered many coping / adaptation measures for the farmers, fishers and seed producers. These were analysed and presented in the order of preference in table 4.8 to 4.10.

Table 4.8 Coping/adaptation measures suggested by Experts for Farmers (n= 20)

Coping Measures Suggested by Experts for Farmers	Response (%)#
Short-Term Measures	
Short-duration fish grow-out	40
Adoption of BMP	25
Net fencing around the pond	25
Strengthening of pond dyke	20
Stocking of advanced fingerling	15
Deep water paddy-fish integration	15
Culture of indigenous fishes for short period	10
Stocking of self-recruiting species like Mola, etc.	10
Harvesting of fish before heavy rain	5
Multiple stocking and multiple harvesting	5
Overwintering of fish seed	5
Stocking of fish during post monsoon season	5
Long-Term Measures	
Increase dyke height to prevent flood control	25
Culture of hardy & stress tolerant fish varieties	15
Promoting species diversification	15
Climate smart aquafarming	10
Integrated farming approach	10
Increase pond depth	10
Using solar pump to compensate water loss	5
Adopting Indoor culture system (RAS, Biofloc, etc.)	5
Technology Infusion for Env. Improvement & Disease Control	5
Training and awareness on climate change	5
Value addition in Fish and Fishery Products	5

Respondents offered more than one measure

Table 4.9 Coping /adaptation measures suggested by Experts for Fishers (n= 20)

Coping Measures Suggested by Experts for Fishers	Response (%)#
Short-Term Measures	
Pen culture in wetlands	50
Creation of deep pool in wetlands	40
Cage culture in wetlands	20
Raising of fry to fingerlings in cage/pen for stocking	10
Seed ranching to increase native stock	5
Katal Fishing	5
Long-Term Measures	
Fisheries and Resources Monitoring System for Wetlands	15
Fish seed raising in paddy field & using them as stocking materials	10
Conservation measures for small indigenous fish species	10
Fish Stock Assessment of Wetlands	5

Respondents offered more than one measure

Table 4.10 Coping / Adaptation measures suggested by Experts for Hatchery Operators/Seed growers (Listed during KII) (n= 20)

Coping / Adaptation Measures Suggested for Hatchery Operators	Response (%)#
Short-Term Measures	
Quality Enhancement of Brood stock	40
Early and Extended Breeding	35
Quality improvement in Seed Production	20
More varieties of fish species for breeding	15
Long-Term Measures	
Development of Hardy and Stress-tolerant Fish Varieties	25
R & D programs on breeding, hatching and rearing	15
Developing Breeding Technologies for Indigenous Fish Species	10

Respondents offered more than one measures

In management term, the gap analysis involves the comparison of actual performance with potential or desired performance. The study revealed the areas that can be improved in the aquatic food production system of Assam for enhanced resilience (table No. 4.11 and graph No. 4.6). The gaps identified by the experts in aquaculture sector are: gap in knowledge and awareness, lack of proper extension services, improved early warning system and availability of information, non-adoption of BMP, lack of disaster preparedness, lack of quality seed and feed. Likewise, in seed production sector, the gaps identified by the experts are: lack of quality brood stock, non-adoption of BMP in seed production, and lack of proper package of practices for fish breeding and seed production. The identified gaps can be bridged through relevant action plans suitably chalked out at the strategic as well as at the operational level.

Table 4.11 Gaps identified by Experts in the Adoption of Climate-Resilient Practices (n= 20)

Gaps identified in adoption of climate-resilient practices	Response (%)#
In Aquaculture	
Gap in advanced knowledge and awareness	55
Lack of proper extension services	45
Improved early warning system and availability of information	5

Non-adoption of BMP	5
Lack of early warning system for fish farmers	5
Strengthen disaster preparedness	5
Lack of quality feed	5
Lack of quality seed	5
In Seed Production	
Lack of quality brood stock	10
Non-adoption of BMP in seed production	5
Lack of technique and standardization for indigenous fish breeding	5
Lack of proper package of practices for fish breeding and seed production	5

Respondents identified more than one gap

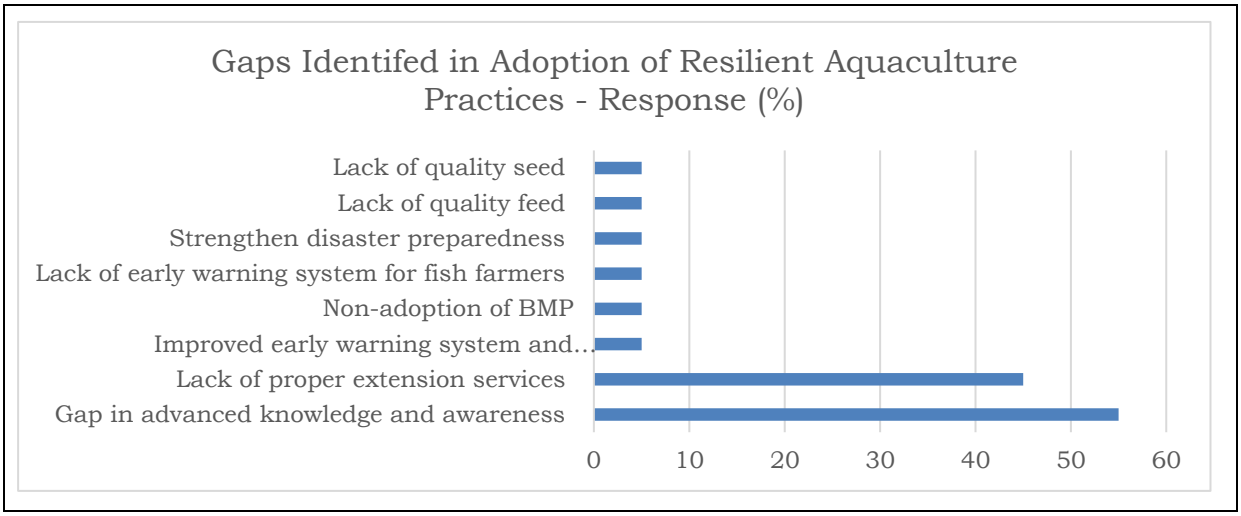


Figure 4.6 Gaps identify by Experts in the Adoption of Climate-Resilient Practices (% of respondents)

The views of the experts were sought about the impact of climate change on fish value chain through KII. Depending on the nature of impacts, they were classified into two categories: positive and negative. Though many impacts identified by the experts were negative in nature; some positive impacts were also recognized (table 4.12). The climate change has overall brought two positive impacts; (i) extended breeding period due to prolonged summer, and (ii) higher growth rate during grow-out phase due to rise in temperature and prolonged summer. The negative impacts were: (i)hampering of hatchery operations due to erratic rainfall, (ii) increase in feed cost due to high cost of ingredients, (iii) entry of predatory and unwanted fishes in grow-out and brood-stock ponds during

flood, and (iv) change in breeding periodicity of fish due to changes in precipitation.

Table 4.12 Climate Change impact viewed by Experts on Fish Value Chain (n= 20)

Climate Change impact on Fish Value Chain (Negative / positive impacts, Direct / indirect Impacts)	**Response (%)#**
Extended breeding period due to prolonged summer	↑ 30
Rise in temperature and prolonged summer provide opportunities for grow-out	↑ 25
Hampering hatchery operations due to erratic rainfall	↓ 10
High cost of fish feed	↓ 10
Entry of predatory & unwanted fishes in grow-out and brood-stock pond during flood	↓ 10
Destruction of breeding & feeding ground of fishes due to flood, pollution and eutrophication	↓ 10
Frequent flood hampering production and fish growth	↓ 5
Changes in precipitation affect breeding periodicity of fish	↓ 5

Respondents offered more than one impact

Tackling the climate change is tough, but at the same time it is also a huge business opportunity. The climate-smart approaches in aquatic food production system should address three key objectives: (i) achieving sustainable production system with considerations on environmental, social and economic aspects, (ii) building resilience to cope with the impacts of climate variability, and (iii) where possible, contribute to the mitigation of greenhouse gases emissions throughout the value chain. In KII, experts were requested to list out the investment requirements in different areas like seed production, aquaculture, health management, fishery development in wetland, development of fishery related infrastructure and facilities, etc. Table 4.13 represents the suggested areas for climate-smart investment options in the order of preference for the fisheries sector in Assam. The major areas for investment proposed by the experts were: construction of hatcheries and rearing space for quality seed production, integrated fish farming system, Fish feed production units, fish disease diagnosis laboratories, development of cold storage and hygienic fish marketing facilities, cage culture in wetlands and Water and soil testing laboratories. The other areas of investment listed by the experts were: pen culture in wetlands, aquaponics, selective breeding of fishes, promotion of float farming, farming of disease resistance fish species, proper management of wetland, promoting stocking of local small indigenous fish species, solar fish drier, rearing pond construction, mainstreaming climate-smart fishery, live fish transportation

system, biofloc system, aid to national agricultural investment and investment in culture system diversification .

Table 4.13 Climate-smart Investment Opportunity in Fisheries (n= 20)

Climate-Smart Investment Opportunity in Fisheries (Listing out the investment requirements in different areas like seed production, aquaculture, health management, fishery development in wetland, development of fishery related infrastructure and facilities, etc)	**Response (%)#**
Construction of hatchery & rearing space for quality seed production	50
Integrated fish farming system	25
Fish disease diagnosis laboratories	20
Development of cold storage and marketing facilities	20
Fish feed production unit	20
Cage culture in wetlands	20
Water and soil testing laboratories	15
Pen culture in wetlands	10
Aquaponics	10
Selective breeding of fishes	10
Promotion of float farming	5
Farming of disease resistant fish species	5
Proper management of wetland	5
Promoting stocking of local small species	5
Solar fish drier	5
Rearing pond construction	5
Live fish transplantation system	5
Main streaming climate smart - agriculture/ fishery	5
Biofloc system	5
Aid to national agricultural investment	5
Investment in system diversification culture system	5

Respondents listed out more than one area

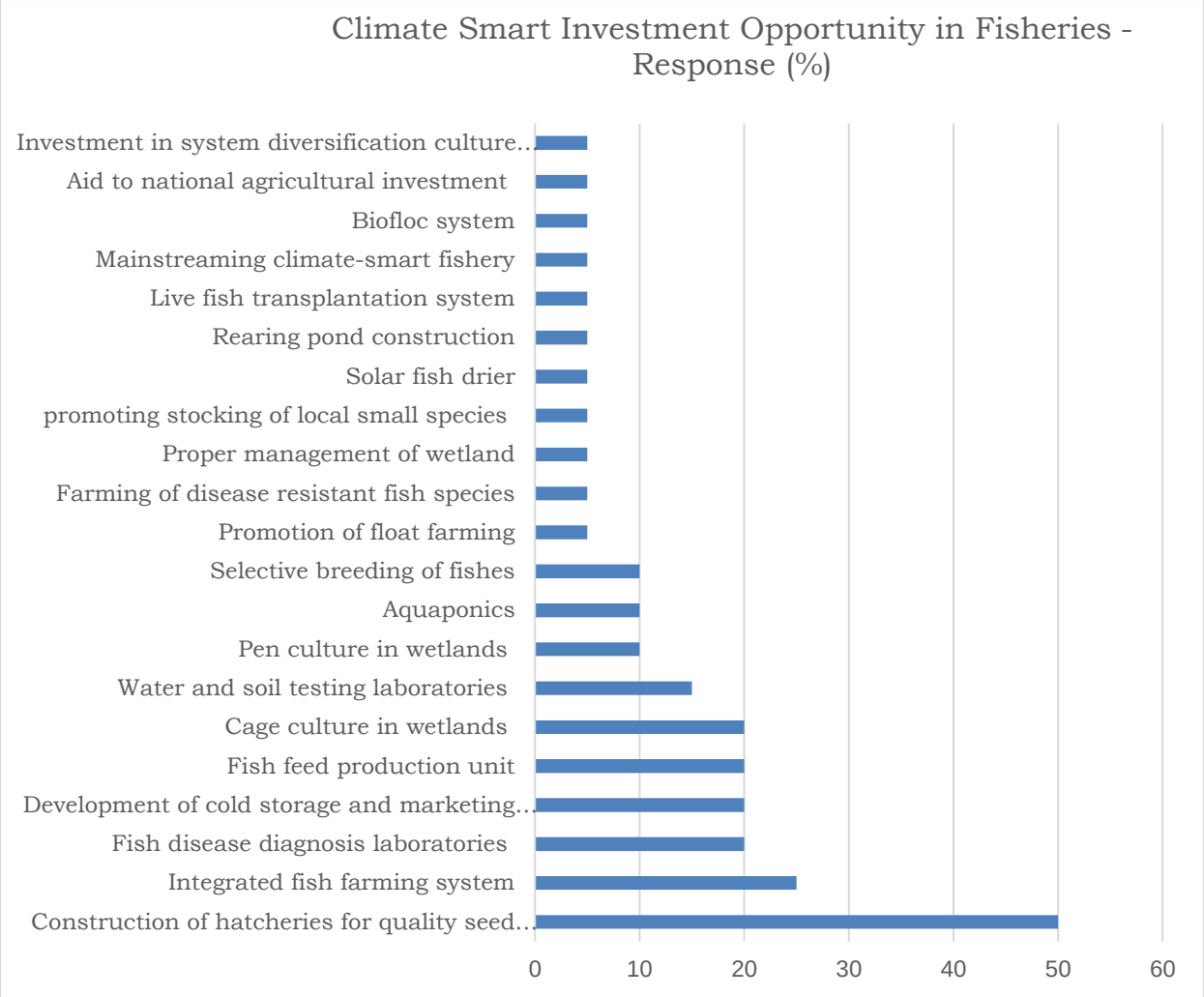


Figure 4.7 Climate Smart Investment Opportunity viewed by Experts in Fisheries (% of respondents)

State level plan is crucial for long-term adaptation strategy. During KII survey, the experts were requested to suggest some potential schemes which could be considered as a part of state level adaptation plan for the Govt. of Assam to implement in fisheries sector. A good number of activities were proposed by the experts for inclusion in Govt. schemes (table 4.14 and Figure 4.8). Few prominent suggestions were: (i) scheme for production of quality fish seed, (ii) scheme for short term fish culture, (iii) scheme to establish fish feed mill, (iv) subsidies for cage culture, (v) scheme for Beel fisheries management, (vi) development of breeding protocol for SIS, and (vii) scheme for integrated watershed management.

Table 4.14 Schemes suggested by Experts for State Level Adaptation Plan (n= 20)

Schemes suggested as a part of state level adaptation plan for the Govt. to implement	Response (%)#
Scheme for production of quality fish seed	20
Scheme for short term fish culture	15
Scheme to establish fish feed mill	15
Subsidies for cage culture	15
Scheme for *Beel* fisheries management	10
Development of breeding protocol for SIS	10
Scheme for Integrated watershed management	10
Scheme for Climate smart aquaculture	5
Scheme for mobile disease diagnosis laboratory	5
Scheme for fish transport vehicle	5
Scheme for Integrated fish farming	5
Scheme for Fingerling stocking in wetland/reservoir	5
Crop insurance scheme for aquaculture farmers	5
Scheme for fish seed raising	5
Scheme for Culture of SIS	5
Scheme for IMTA	5
Declaration of inland protected areas for conservation	5
Scheme for pearl culture	5
Scheme for Cage culture in wetlands	5
Scheme for RAS/ Biofloc Technology	5
Scheme for Species diversification in aquaculture system	5
Scheme for Paddy cum fish culture	5
Scheme for Aqua tourism	5
Scheme for Pen culture in wetlands	5

Respondents offered more than one suggestion

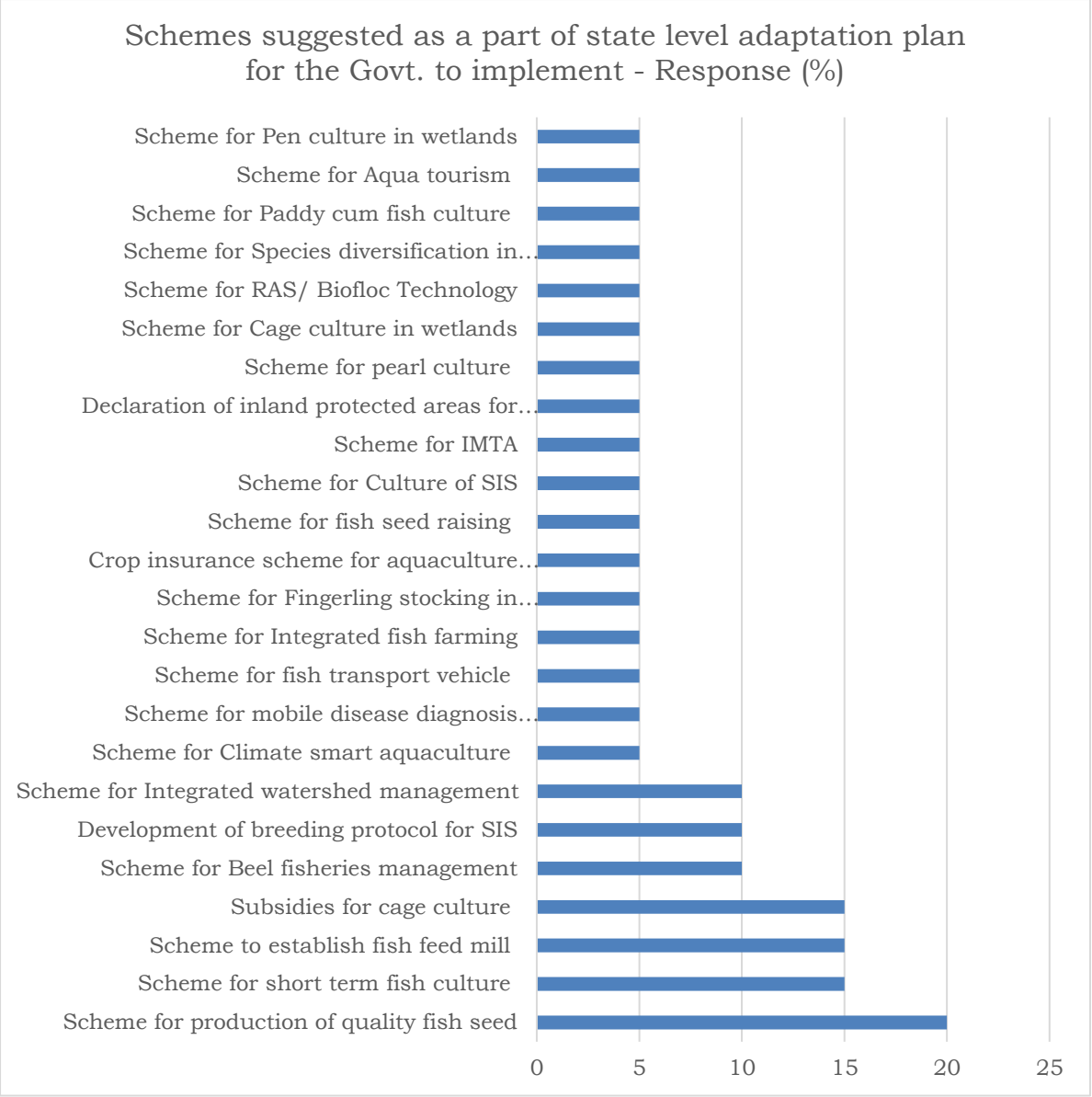


Figure 4.8 Schemes suggested by Experts for State Level Adaptation Plan

Photos on Consultation & Survey

Interaction with Officials at Dept. of Fisheries, Govt. of Assam

Visit to Office of the ARIAS Society, Guwahati

Interaction with Faculty members at College of Fisheries, AAU, Raha

Inception Workshop at SIPC Conference Hall, WorldFish-Guwahati

Focus Group Discussion on Pond Fisheries (Kamrup-Metro District)

Discussion with the Scientist of ICAR-CIFRI, Guwahati

Visit to Digholi *Beel*, Kamrup (Rural) District

Witnessing the harvest of Freshwater prawn (Kamrup-Metro District)

Displaying the harvested Freshwater prawn (Kamrup-Metro District)

Visit to Fish Seed Hatchery, Sutarpur, Nilbagan, Hojai

Visit to local NGO Kalong-Kapili (Kamrup-Metro District)

Use of solar powered pump in fish pond (Nagaon District)

Pig-Fish Integration (Nalbari District)

Duck-Poultry Shed (Duck at bottom & Poultry on top) - Nalbari District

Fish harvesting from Paddy-Fish unit (Nalbari District)

Interacting with farmer Mr. Ganesh Chandra Roy, Pub-Barala (Barpeta)

Nylon net fencing against escape of fish during flood (Barpeta)

Dyke protection by erecting bamboo fencing (Nalbari)

Focus Group Discussion on Pond Fisheries (Nalbari District)

Group photo of Participants of FGD on *Beel* Fisheries

Focus Group Discussion on *Beel* Fisheries (Kamrup-Rural District)

Focus Group Discussion on Fish Seed Production (Nagaon District)

Focus Group Discussion on Polyculture of carp with *mola* (Nalbari District)

Witnessing the harvest of *mola* (Nalbari District)

4.3 Participatory Rural Appraisal (PRA) for Local Level Adaptation Plan

Participatory Rural Appraisal (PRA) is a process which involves participatory approaches and methods that emphasize local knowledge and enable local people to do their own appraisal, analysis and planning (World Bank, 1995). PRA uses group information and exercises to facilitate information sharing, analysis and action among stakeholders. In India, the Conventional "top-down" approach is generally followed in planning and implementation of projects, where planning is made by the top-level executives and same is implemented at ground level. This approach however, doesn't address the constraints and development potentials of the local people in a comprehensive way. On the contrary, PRA is the reversal from "top-down" to "bottom-up" approach, where the people and the local communities are involved in analysis of their own problems and make plan that receive approval from the top level. Over the years, PRA has gained popularity as an effective process in planning and execution of project as it is more responsive to local people and local situations.

PRA can be used as an effective process to develop community level adaptation plan on climate change. This helps the local communities to systematically assess their situation and to know clearly what they need to best adapt to climate change impacts. In the present study, due to the time constraint, only one PRA exercise could be done. The purpose here is only to demonstrate the use of PRA as an effectively tool in strategizing the local level adaptation plan in Aquatic food Production System. This can be used as a conceptual framework to project PRA as a useful process in local level climate change adaptation plan.

4.3.1 Constituents of PRA Team

There were three prime constituents of PRA exercise; 'team', 'tools and techniques' and 'sources of information'. The PRA exercise was conducted at Bagibari Village in Sonapur Block under Kamrup (M) district of Assam. It was organised in collaboration with Kalong-Kapili, a local NGO. Total 36 villagers, both men and women, took part in PRA exercise (list of participants in annexure –). Different tools and methods (as detailed under methodology) were used in various combinations to suit the local context. Diverse sources of information were used and these included people, place and environment. To ensure active participation from the villagers, less writings and more of oral communication and tools of like pictures, symbols, physical objects and group memory were used. The PRA was designed specifically to address following objectives:

- To understand the peoples' perceptions of climate change by identifying and ranking some of the main climate change parameters and related hazards over the last 30 years.
- To record the major climate induced impacts on the aquatic food production system of the area
- To collect the feedback from the villagers on the climate resilient aquaculture technologies being implemented in the village through APART.
- To seek opinions on some unconventional issues like gender involvement in fisheries and aquaculture activities, matrix ranking of different aquaculture activities, seasonality chart, problem diagram with ranking, etc.

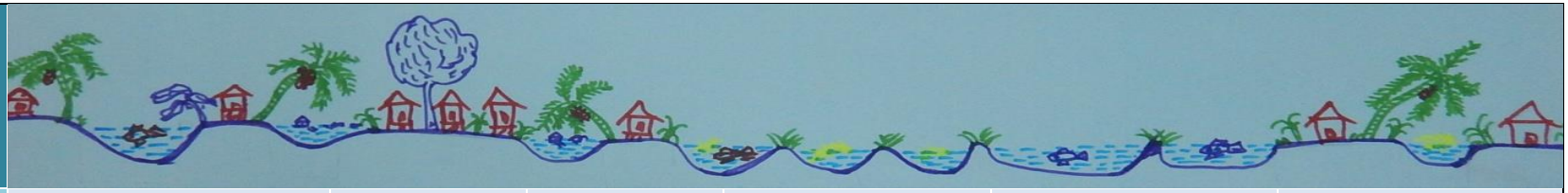
4.3.2 Transect analysis of village

Transect walk is an observatory trek across the village to gets insights and introduction into the nature and complexity of farming, resources and management which conventional approaches do not usually offer. The village transect analysis (table 4.15) represented the cross section of Bagibari village indicating topography, soil type, crops grown, fishery resources, livestock details etc. The village has undulating topography like any other village of Assam. Many small and medium size ponds are seen spread in and around the village. Few years back, villagers used to culture fish in these ponds in traditional way. However, with the implementation of different Government schemes including APART, farmers are now adopting scientific farming. Villagers are currently involved in carp polyculture, carp polyculture with freshwater prawn and carp polyculture with mola.

4.3.3 Land Use Map of the Village

The land use map of Bagibari village, drawn by the villagers, gave a bird's eye view of the village in totality. It gave a fairly good idea about the settlement pattern of houses, availability of infrastructure, land use pattern, religious and social institutions located in the village. The village is near the Kolong river. Hinduism is the dominant religion in the village. Agriculture, animal husbandry and fishery are the major livelihood and economic activity in the region.

Table 4.15 Transect analysis of Bagibari village

Transect Map (drawn by villagers)						
Soil type	Loamy clay	Loamy	Loamy clay	Clay	Clay	Loamy clay
Topography	Gently undulating	Plain	Gently undulating	Depression	Depression	Gently undulating
Vegetation	Trees, bushes, weeds	Trees, bushes	Trees, bushes, weeds	Aquatic weeds	Aquatic weeds	Trees, bushes, weeds
Crops	Betel nut, Coconut	Banana, Lemon, Betel nut, Coconut	Betel nut, Coconut, Lemon	Banana, Papaya, Paddy	Banana, Papaya, Paddy	Banana, Lemon, Betel nut, Coconut
Livestock	Cattle, Duck	Cattle, goat, pig, duck, chicken	Duck	Duck	Duck	Duck, pig, chicken
Fishery	Carps (IMC & exotics), Freshwater Prawn, Mola	-	Carps (IMC & exotics)	Carps (IMC & exotics)	Carps (IMC & exotics), mola	Carps (IMC & exotics)
Water depth	3-4 ft	-	3-4 ft	4-5 ft	4-5 ft	3-4 ft
Productivity	Good	Good	Good	Very good	Very good	Good

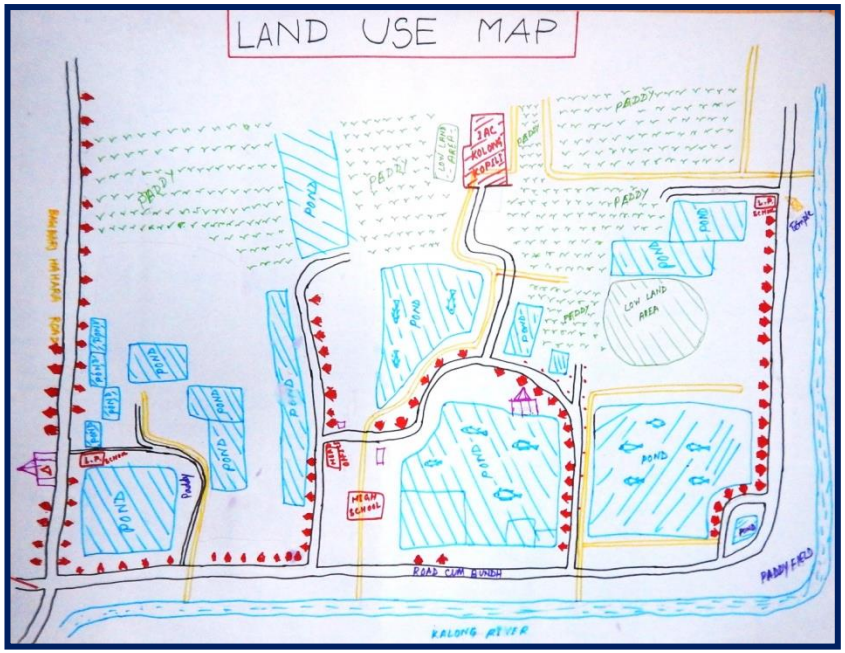


Figure 4.9 Land Use Map of Bagibari Village
(Drawn by villagers on chart paper)

Figure 4.10 Land Use Map of Bagibari Village
(Drawn by villagers on floor with colour powder)

4.3.4 Timeline

The important events pertinent to the village and the aquaculture development in the locality are depicted below in the form of time line. The village experienced natural calamity in form of flood in 1988. The embankment along Kalong river, constructed in 1958, gave long-term physical protection to the village from flood. Freshwater prawn culture was initially introduced in the village by NABADB in 2014 with limited success. However, it was re-introduced in 2019-20 through APART project and this time it was a full-fledged success.

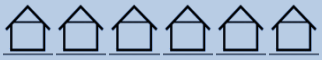
Table 4.16 Timeline of Bagibari Village

Year	Event
1950	Establishment of Primary School
1958	Construction of embankment of Kalong River
1970	Arrival of electricity
1972	Canal irrigation
1974	Introduction of *Boro* paddy
1982	Arrival of TV
1988	Occurrence of major flood
1995	Construction of metal road
2000	Construction of brick kiln in nearby area
2002	Arrival of Cable TV
2007	Starting of Scientific fish farming & use of Fish Feed
2014	Starting of Freshwater Prawn Culture
2018	Installation of deep tube well for agriculture
2021	Occurrence of mild drought

4.3.5 Trends and Changes

Information on trends and changes over the last 30 years of the area were collected from the elderly villagers and depicted with the help of various symbols in Table 4.17. This figure only shows the trend and not the proportionate numbers. The population has steadily increased and has nearly doubled during the above period. The total number of houses in the village have also increased proportionately. The literacy percentage of the villagers (male and female) has shown increasing trend. The production of paddy and fish have increased over the years as farmers are adopting scientific farming and using more input for better returns. Areas under scientific fish farming have increased and more farmers are using supplementary feed in fish ponds. Freshwater prawn farming has been introduced in recent years only. Use of toilet has increased considerably over the years and so as the tube well for drinking water. Improvements have happened in home cooking front. Cooking gas is gradually replacing the firewood as medium of cooking due to many reasons like scarcity of firewood, easy availability of cooking gas at subsidized rate and others health benefits.

Table 4.17 Depiction of trends and changes in Bagibari village over 30 years

Year	1991	2006	2021
Population			
House			
Literacy			
Use of tube well			
Paddy Farming			
Fish farming			
Pawn Farming			
Use of Fish feed			
Toilet at home			
Use of fire wood			

Use of cooking gas			

4.3.6 Resource Flow Map

The villagers of Bagibari depend on the outside areas for meeting their needs to some extent and rest are met within the village. Majority of the villagers are farmers and are engaged in full-time agriculture, horticulture animal husbandry and fisheries. The labour requirement for farming is met within the village and the surplus goes outside. However, critical inputs like seed, feed, chemical fertilizer, etc. are brought from outside. The surplus farm products like paddy, vegetables, fish, meat, milk, etc. are sent outside after meeting the internal requirements of the village. The resource-flow map (Fig 4.11) used the diagrams and visual lines to explain the flows, interactions and linkages between the resources.

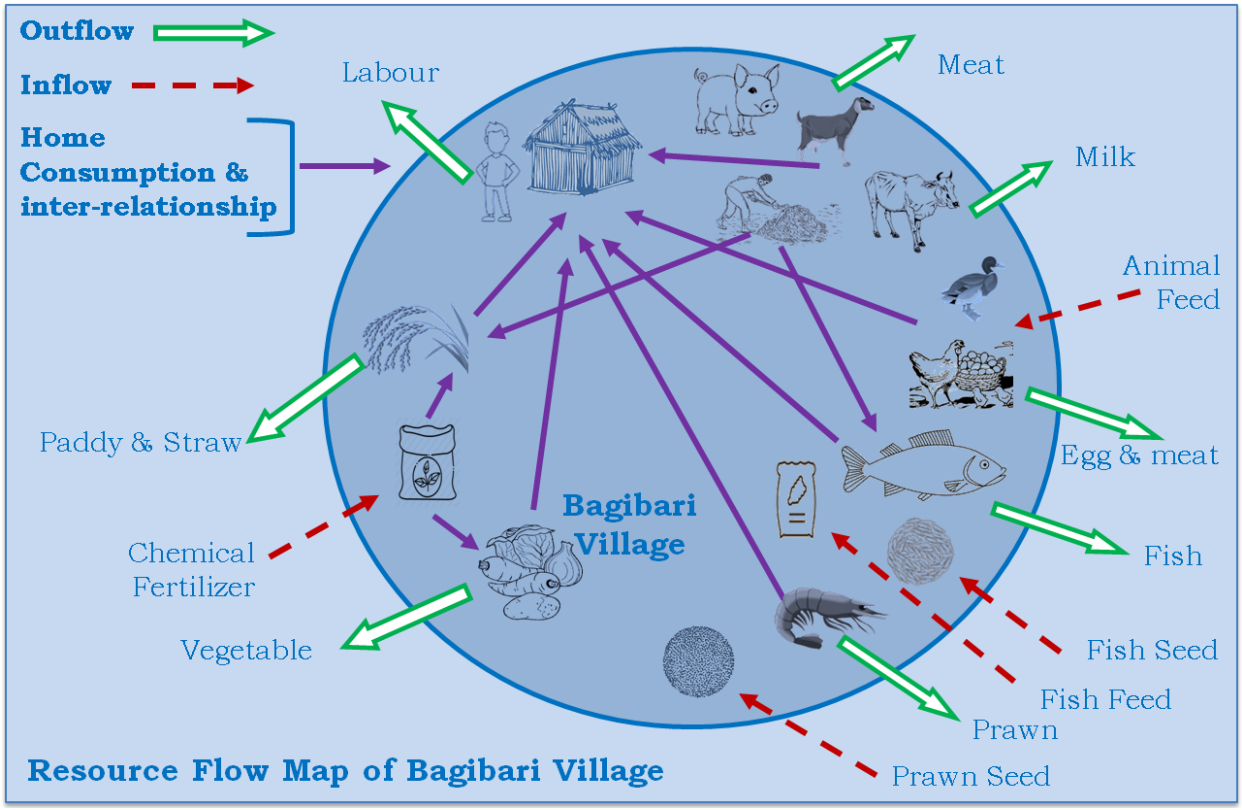


Figure 4.11 Resource flow map for Bagibari village

4.3.7 Mobility Map

Bagibari village has primary school, Anganwadi (child and mother care) centre, office of an NGO, temple and play ground. The villagers frequently go to Kolongpar market, which is located at a distance of 5 km for weekly market and to sell fish. Khetri is next nearest place where there are police station,

small hospital and college. Sonapur town is located at about 15 km distance from the village. It is the block headquarters and facilities like block-level office, hospital, banks, college are located here. The mobility map of the Bagibari village is depicted below as figure 4.12 through Venn diagram.

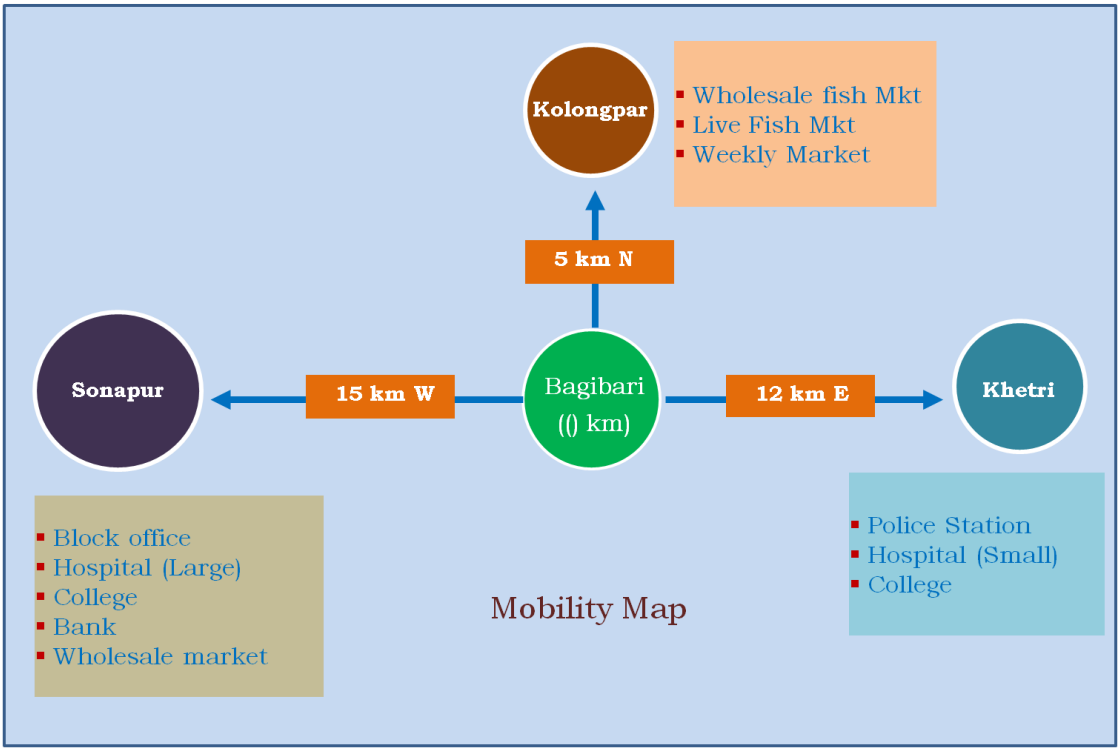


Figure 4.12 Mobility map for Bagibari village

4.3.8 Gender Analysis

Gender analysis describes the different roles and responsibilities between men and women in social, economic, cultural and political contexts. Gender study is a complex one as only part of it can be observed outside the household and a large part of gender dynamics take place within the four walls, making it difficult to comprehend within a short period of time. However, the PRA encompassing effective tools helped to understand the extent of participation of men, women and both in different activities with regards to aquaculture. The study revealed that the men overwhelmingly participate in different aquaculture activities (68.75%), followed by joint participation of men and women (20%). Very few women (11.25%) are exclusively involved in aquaculture activities. The activities like fish harvesting, marketing, liming, stocking, sampling, routine management, etc. are dominated by men. It is interesting to note that in the event of natural calamities like flood, both men and women spring in to action to protect the fish crop.

Table 4.18 Gender and Age Group Involvement in Aquatic Food Production System

Activities	Gender			Age Group		
	Men	Women	Both	Children	Adult	Old
Decision on species for Aquaculture	6	2	2	X	4	6
Purchase of Seed and Feed	6	2	2	X	10	X
Feeding Fish	5	2	3	1	7	2
Liming, Stocking, Sampling & Routine Management	9	X	1	X	10	X
Coping Measures during Flood	2	2	6	2	6	2
Catching Fish for domestic consumption	7	1	2	1	8	1
Harvesting Fish for Sale	10	X	X	X	10	X
Fish Marketing	10	X	X	X	10	X
Total Score	55	9	16	4	65	11
Percentage (%)	68.75	11.25	20	5	81.25	13.75

4.3.9 Matrix Ranking

Matrix ranking technique involves scoring and ranking items to reveal priorities and preference. Villagers' preference towards different interventions was revealed by this technique. Matrix ranking is most appropriate when outsiders wish to obtain precise information on relationship amongst several criteria and wish to rank only a few alternatives related to uses, preferences and priorities. In a matrix ranking exercise, different attributes and criteria were ranked on the basis of scoring (e.g., assigning a score out of 10) according to their relative importance and listed in matrixes. A perusal of Table 4.19 revealed that carp polyculture with mola is the most preferred enterprise by the farmers followed by carp polyculture and then carp polyculture with freshwater prawn.

Table 4.19 Matrix Ranking of Aquaculture Activity in Bagibari village

Attributes	Carp Polyculture	Carp Polyculture with F W Prawn	Carp Polyculture with Mola
High Yield	8	9	9
High Unit Sale Price	9	10	8
High Profit	8	9	9
Easy Seed Availability	9	2	9
Easy Feed Availability	8	7	8
Disease Resistance	8	9	9
Low Risk Involvement	9	6	9
Easy Management	8	7	9
Total Score	67	59	70
Ranking	II	III	I

4.3.10 Seasonality

Seasonality is a tool used to study the variations in different activities / parameters according to seasons. In the present study, the information pertaining to various activities and events in fish farming, namely pond preparation, liming and manuring, seed stocking, feeding, harvesting, disease occurrence, water quality problem, water stress condition, flood danger, etc.

were collected through discussion with farmers and plotted against the months. Over the last two decades or so, the farmers are observing erratic rainfall. In some years, it rains heavily either at the beginning or the end of the monsoon and rains very little in the middle of the rainy season and thus affecting aquaculture adversely. Farmers are experiencing hot summer and short winters. Many attributed these to climate change. In their opinions, aquaculture is getting adversely impacted due to these climate-induced changes. The activity calendar and seasonality chart as perceived by the villagers is shown in table 4.20.

Table 4.20 Activity Calendar and Seasonality Chart

Activities /Occurrence	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pond Preparation												
Liming and Manuring												
Seed Stocking												
Feeding												
Harvesting												
Disease Occurrence												
Water Quality Problem												
Water Stress Condition												
Flood Danger												

4.3.11 Problems Identification

During PRA exercise, emphasis was given to identify the problems faced by the farmers in different interventions. The identified problems were subjected to problem-cause analysis and ranked through causal diagrams depicted below (figure 4.13 & 4.14). The major problem in carp polyculture was poor availability of feed, followed by lack of quality seed. Other problems identified by the farmers were high price of input, disease outbreak and non-availability of disease diagnosis facilities. Likewise, in carp polyculture with freshwater prawn, major problem was lack of freshwater prawn seed due to non-availability of freshwater prawn hatchery in Assam. The other problems identified by the farmers were poor availability of feed, lack of training and disease problem.

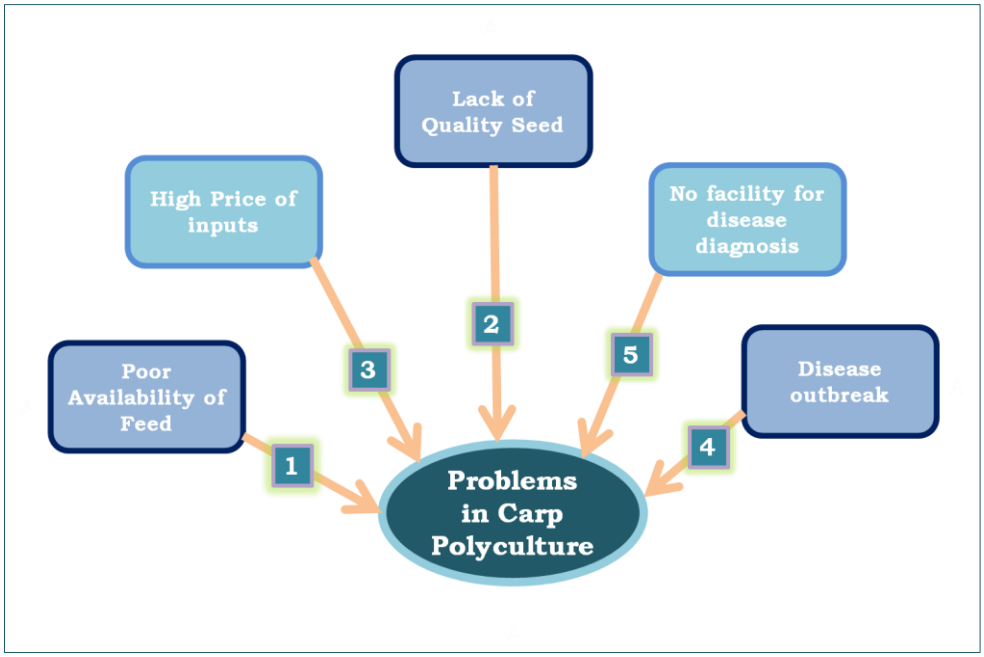


Figure 4.13 Problem diagram with ranking in carp polyculture

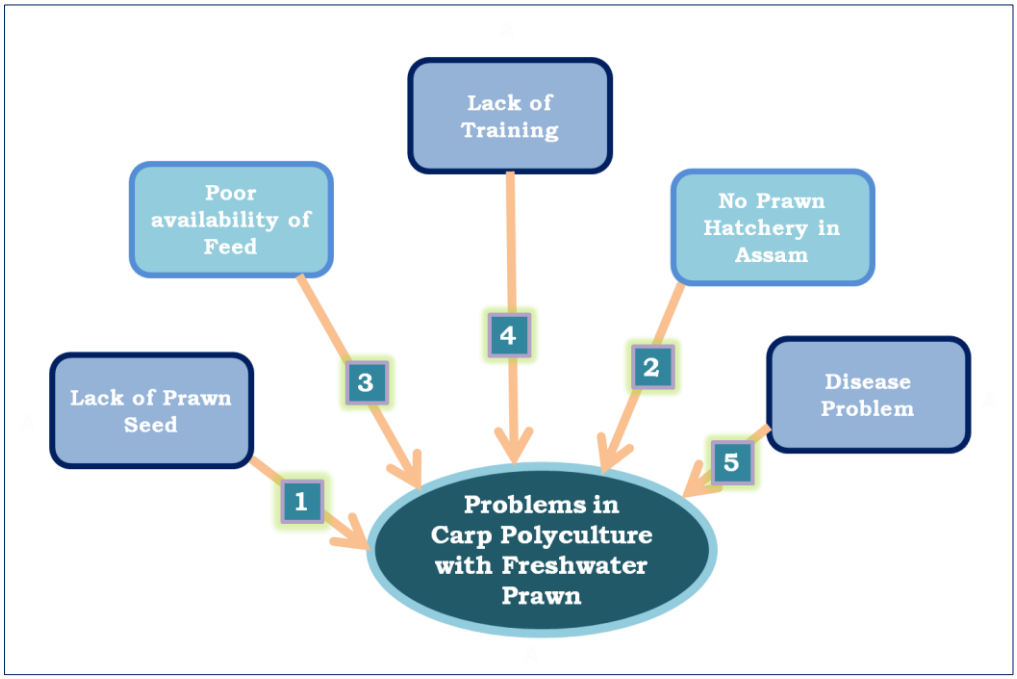


Figure 4.14 Problem diagram with ranking in carp polyculture with Freshwater Prawn

4.3.12 Voices from the community

During PRA, the participants were encouraged to speak out freely about the APART project, its impact on the society and their suggestions. Few prominent voices are quoted below.

APART project is a good initiative of the Government for overall development of aquaculture activities in the area. Fish farmers are being benefitted from the project. We are grateful to the project officials.

- An elderly man of the Village

Introduction of Freshwater prawn in carp polyculture is showing good results. Farmers are very much eager to continue the activity. APART project is requested to arrange freswater prawn seeds for stocking this time also.

- A prominent fish farmer of the area

Project staffs visit our village frequently and extend all types of help. It is a nice gesture.

- A young man of the village

This is the first time any agency is making us aware of the project being implemented in our area and asking our expectation from the project for the development of our village. We heartily appreciate the effort.

- An educated man of the area

Many women of the village are beneficiaries of the project and are actively involved in project activities. Thank you for the support.

- A female respondent from the village

Such camp (PRA exercise) at regular interval in the village will be helpful for us.

- A fish farmer of the area

No doubt, we are experiencing the change in climate. Therefore, we welcome the climate adaptive farming technologies promoted under the project.

- A middle aged man of the village

Photos of PRA Exercise

Registration during PRA workshop

Explaining objectives of PRA

Engaging different Breakaway Groups in PRA exercise

Participants engaged in Resource Flow Analysis

Engaged in matrix ranking exercise

Problem Identification Exercise

Participants writing opinions

Participants drawing village map on floor

Group photo with village map drawn by villagers

Display of charts prepared by PRA team

Group Photo with charts at the background

Lunch at the end of PRA Exercise

5 Evaluation of Fishery Technologies implemented by APART

5 Evaluating Fishery Technologies of APART

The aquatic food production system of Assam requires climate-resilient technologies and innovative practices to cope with the increased climate risks. Developing and promoting the climate-resilient technologies in support of sustainable aquaculture and small-scale fisheries is one of the broad objectives of the fisheries sub-component of APART. The climate resilient technologies which are being demonstrated under APART to facilitate adaptation to the impacts of climate change at the local level are listed below.

1. Short Duration Fish Culture
2. Overwintering of Seed (Stunted Yearling Production)
3. Paddy-cum-Fish Integrated Farming System
4. Polyculture of Carps in Pond
5. Multiple Stocking and Multiple Harvesting of Carp
6. Carp polyculture with *Mola* and other SIS
7. Polyculture of Carps and Fresh Water Prawn
8. Cage culture in *Beels* for fingerling & table fish
9. Production improvement in *Beels* through stock enhancement

5.1 Evaluation of Fishery Technologies promoted under APART from climate resilience perspective

In the present study above technologies/ interventions in the fisheries sub-component of APART project were evaluated through the collection of filed data and screening them through the lens of adaptation to climate change. After careful consideration of type and nature of data collected, a common evaluation framework was developed to appraise the said technologies. The framework comprised several attributes such as: - (i) Key Features, (ii) Geographical Spread of Demonstration, (iii) Adaptation Hypothesis, (iv) Adaptation Benefits, (v) Production Results, (vi) Driving Forces, (vii) Restraining Forces, (viii) Actors Involved, (ix) Sustainability, (x) Replicability, (xi) Over-arching Impact (Economic, Social and Ecological), (xii) Institutional Mechanism and (xiii) Learnings.

5.1.1 Short Duration Fish Culture

Name of the Intervention	Short Duration Fish Culture
Key Features	It is the practice of raising Indian major carps (IMC) to a suitable table size fish in a short duration of 80-90 days. The table fish of size 100-350g which are preferred in restaurants and locally

		referred as 'Hotel Fish'. Here the fish culture is taken up in post-winter and pre-flood period, *i.e.,* during February to May. The fingerlings of Catla (50-60g size), Rohu (40-50g size), and Mrigal (30-40g size) are stocked at the density of 40,000 nos./ha. in the species ratio of 40:50:10. Fishes are fed with mustard oil cake and rice polish in the ratio of 60:40. This is meant for supplying fish to the consumers during summer months which is basically lean and non-fishing period and fish price is high.
Geographical Spread of Demonstration		15 demonstrations were conducted during 2019-20 in 15 districts; average size of each demonstration pond was 0.25 ha. (Kokrajhar, Barpeta, Nalbari, Goalpara, Jorhat, Morigaon, Kamrup, Lakhimpur, Dhubri, Darrang, Sonitpur, Nagaon, Cachar, Golaghat and Sivasagar)
Adaptation Hypothesis		Shortening of culture duration will reduce the sensitivity of the fish production and will make fish farms less vulnerable to the climatic extremes like flood.
Adaptation Benefits		1. Reduced Sensitivity: Makes the farming less sensitive to production loss in the event of flood 2. Reduced Vulnerability: Makes the farmers less vulnerable to economic loss in the event of flood 3. Improved Adaptive Capacity: Being a remunerative activity, it improves the adaptive capacity of the farmers to cover up the financial loss during the climatic extremes like flood etc.
Production Results		The production rate is 6.0-7.5 t /ha. /Crop, which is quite high. Success rate was high during demonstration.
Driving Forces		Very good market for the produce (Hotel-Size Fish). The demand is likely to grow more in future due to increasing popularity of sub-adult IMC for consumption.
Restraining Forces		Access to advanced fingerlings for stocking
Actors Involved		Fish seed growers, Farmers and Traders
Sustainability		High. Technically feasible, financially viable and environment friendly
Replicability		High, the practice is spreading to new areas
Over-arching Impact	Economic	Increase in income
	Social	Nutritional security for local community Enhanced resilience for participating farmers
	Ecological	Eco-friendly activity. No adverse impact on soil and water quality.
Institutional Mechanism		Institutional arrangements between farmers, DoF, College of Fisheries and ARIAS Society facilitate the better adoption of the technology.

Learnings	▪ Need to synchronise the seed growing strategy with the short duration fish culture for timely supply of stocking material at required quantity. ▪ Strengthening the facilities for transportation and marketing of hotel-size fish in live condition. ▪ Customising and fine-tuning the technology in local context. ▪ Dissemination of technology through training and demonstration for scientific adoption. ▪ Though evolved as climate resilient practise for flood affected areas, gradually gaining popularity in other areas also. ▪ Besides restaurants, the hotel-size fish are preferred for household consumption as well.

5.1.2 Overwintering of Seed (Production of Stunted Yearling)

Name of the Intervention	Overwintering of Seed (Production of Stunted Yearling)
Key Features	Assam is characterised by dry and cold winter season starting from October-November to January-February during which the ambient temperature is much below the optimum range for fish growth. Hence, when the farmers stock fish seed during the month of June-July, they get the ambient optimum temperature regime for 3-4 months only for growing the fish. To avail the benefit of optimum temperature regime the fish farmers have to stock their ponds during the month of March-April, but the non-availability of fingerling at the right time of stocking (March-April) has been a bottleneck for development of fish farming sector in the region. Because, the breeding of carp commences with the advent of monsoon during April-May in Assam. But, through the technology of overwintering of seed, large size fingerlings can be made available to the farmers of Assam from March-April onwards. Overwintering of seed is aimed at producing the stunted yearlings of carp and is aptly considered as a climate resilient technology. The rationale behind this technology is rearing the seed at high density with low feeding and less mortality covering the winter months and then stocking the stunted fingerling to have compensatory growth during grow-out phase. The fish, whose growth is arrested as juveniles under partial starvation, is compensated by voracious feeding in grow-out phase.
Geographical Spread of Demonstration	15 demonstrations were conducted during 2019-20 in 13 districts; namely Kokrajhar, Barpeta, Nalbari, Goalpara, Jorhat, Morigaon, Lakhimpur, Dhubri, Darrang, Sonitpur, Nagaon, Golaghat and Sivasagar. The average size of each demonstration pond is 0.25 ha.
Adaptation Hypothesis	Modification in culture technology by reducing the negative impact of winter and enhancing the positive impact of

		summer on growth of the fish will make fish farming less vulnerable to the climate extremes like cold winter and will make entire farming system more resilient.
Adaptation Benefits		1. Reduces the use of feed in fish farming during cold winter 2. Uses stunted fingerling as stocking material in the summer induces faster growth during grow-out phase. 3. Makes fish farming financially more rewarding and climatically more resilient.
Production Results		The production rate is 2800-4400 kg/ha. /Crop of 180-200 days. Average initial wt. of fry is 4-6 g and average harvest size is 85-140 g. Success rate was high during demonstration.
Driving Forces		▪ Good demand for stunted yearling as stocking material for large ponds and *beels* ▪ The technology produces big size fish that fetches premium price in the market.
Restraining Forces		Sudden and sharp drop of temperature in winter may cause mortality
Actors Involved		Fish seed growers, Farmers and Traders
Sustainability		High. Technically feasible, financially viable and environment friendly
Replicability		High. Pens and cages in *beels* can also be also used for overwintering of Seed
Over-arching Impact	Economic	Increase in income
	Social	Nutritional security for local community Enhanced resilience for participating farmers
	Ecological	Eco-friendly activity. No adverse impact on soil and water quality.
Institutional Mechanism		Institutional arrangements between farmers, DoF, College of Fisheries and ARIAS Society facilitate the better adoption of the technology.
Learnings		▪ The activity should start during June-July instead of August-September as the seed price in this period is very low. ▪ Test netting at monthly interval is beneficial for monitoring disease and growth. ▪ The stocking of stunted fingerling will result in harvesting of big size fish due to the compensatory growth in grow-out phase. ▪ Dissemination of technology through training and demonstration for wider adoption.

	▪ Though evolved as climate resilient practise, gaining popularity as a strategy to grow big size fish in short duration.

5.1.3 Paddy-Fish Integrated Farming System

Name of the Intervention	Paddy-Fish Integrated Farming System
Key Features	Paddy and fish are staple diets for the people of Assam and they are grown almost in all agro-climatic regions of the state. In Assam, the nature and type of integration vary largely depending upon the topography of land and other contexts like biophysical and technical considerations. Though paddy field fishery is recognised as traditional practice in the region, of late it is deliberately seen as a productive fishery. It is an extensive level of farming practice using low input technology. The cost and return evaluation showed that paddy-fish culture is more profitable than paddy cultivation.
Geographical Spread of Demonstration	In 2018-19, the demonstration covered an area of 42 ha with 91 beneficiaries in 6 districts. It increased to 100 ha with 206 beneficiaries in 9 districts and 289 ha with 570 beneficiaries in 10 districts for the year 2019-20 and 2020-21 respectively.
Adaptation Hypothesis	Integrating fish farming with paddy cultivation makes the communities less vulnerable to the impacts of climatic event like flood by promoting fish farming as an additional source of income and thereby making the entire system more resilient to adverse climate events.
Adaptation Benefits	1. Ensures total utilization of land and water resources of the farm resulting in maximum and diversified farm output with minimum financial and labour costs. 2. Integration of paddy and fish reduces the risk of total crop failure. 3. Makes the farming financially more rewarding and climatically more resilient.
Production Results	Fish production varied from 0.5 to 1.5 t/ha (major carps & small indigenous species)
Driving Forces	▪ Renewed interest among the farmers as an economic activity especially in flood prone and low-lying areas. ▪ Can be established as organic production system for paddy and fish with certain modifications.
Restraining Forces	Use of pesticides in paddy cultivation is detrimental to fish
Actors Involved	Rice Farmers, Fish Farmers, Fish Seed Suppliers and Traders

Sustainability		High. Enables sustainable increase in aquaculture production without adverse socio-economic or environmental impacts
Replicability		High. New areas especially in flood prone and low-lying regions can be brought under paddy-fish integration
Over-arching Impact	Economic	Increase in income, provides diversified products
	Social	Nutritional security for local community, greater dietary diversity
	Ecological	Eco-friendly activity. Fish and paddy interact eco-biologically, in space and time. They are mutually supportive. No adverse impact on soil and water quality.
Institutional Mechanism		Institutional arrangements between farmers, DoF, IRRI, CoF, WorldFish and ARIAS Society facilitate the better adoption of the technology.
Learnings		▪ Need to stock advanced carp fingerlings (>10 cm) for better production ▪ Chemicals/pesticides banned by Government should be removed from Better Management Practices (BMP). ▪ BINA Dhan 11 is a submergence tolerant rice variety suitable for paddy-fish integration. It is grown both during Kharif and Rabi seasons and can tolerate flooding up to two weeks. ▪ Introduction of air-breathing species like anabas, magur, singhi, etc. along with carps and mola yields better ▪ Amur common carp goes well in paddy-fish integration. Grows even up to 1.5-2.0 kg in 9 months. ▪ In lower Assam districts like Nalbari and Barpeta, farmers give equal importance to both paddy and fish; while in central Assam districts like Morigaon and Nagaon, farmers give more importance to fish and often sacrifice paddy production for fish production.

5.1.4 Polyculture of carps in pond

Name of the Intervention	**Polyculture of carps in pond**
Key Features	Polyculture of carps denotes the culture of several compatible carp species with different feeding types together for the purpose of utilizing productivity at all ecological niches in an aquatic system. Though operated in extensive, semi-intensive and intensive scales; the semi-intensive system where the water productivity is optimised through application of manures and fertilisers, and the nutritive demand of fish is partially met with supply of external feed is more popular than the other two. Ponds are generally stocked with fingerlings @

		8000 per ha. Three species of Indian major carps (Catla, Rohu and Mrigal) and three species of exotic carps (Silver carp, Grass carp and Common carp) are commonly cultured. Minor carps like *L. bata, L. calbasu, L. gonius*, etc. are stocked occasionally along with the above species.
Geographical Spread of Demonstration		15 districts of Assam; namely Kokrajhar, Dhubri, Barpeta, Nalbari, Goalpara, Jorhat, Morigaon, Lakhimpur, Dhubri, Darrang, Sonitpur, Nagaon, Golaghat, Sivasagar and Cachar
Adaptation Hypothesis		Polyculture of carps in scientific way makes fish farming more profitable and enhances the adaptive capacity of the farming communities to the impacts of climatic events mainly frequent flooding in low lying areas.
Adaptation Benefits		1. Ensures fuller utilization of space and food at all ecological niches yielding high production from unit area 2. Creates an ecosystem where pond nutrients are efficiently utilized with minimum waste of bound carbon and nitrogen. 3. Makes the farming financially more rewarding and thereby economically empowering farmers with better adaptive capacity to fight against the negative impacts of climate change.
Production Results		Fish production varied from 5.0 to 6.0 t/ha depending on the management and the level of input use.
Driving Forces		Farmers are readily adopting this technology as it is economically remunerative. Easy availability of critical inputs like seed and feed. Timely guidance from the project staff
Restraining Forces		Localized poaching of fish from ponds, lack of quality seed and feed.
Actors Involved		Farmers, Seed Producers, Input Suppliers and Traders
Sustainability		High. Enables sustainable increase in aquaculture production without adverse socio-economic or environmental impacts
Replicability		High. Under-utilized and un-utilized water bodies can be brought under scientific carp polyculture.
Over-arching Impact	Economic	Increase in income, provides diversified products
	Social	Nutritional security for local community, greater dietary diversity
	Ecological	No adverse impact on soil and water quality when inputs are used responsibly.
Institutional Mechanism		Institutional arrangements between farmers, DOF, COF, WorldFish and ARIAS Society facilitate the better adoption of the technology
Learnings		Test netting at monthly interval will facilitate disease monitoring and growth.

	Fish of > 0.75 kg size are to be harvested for sale periodically to facilitate smaller fishes to grow. When stocked in March, partial harvesting can be done in September. Final harvesting can be done at the end of 10th -11th month of rearing by complete dewatering of pond. Farmers fetch better price, when the harvested fish are live.

5.1.5 Multiple Stocking and Multiple Harvesting of Carps

Name of the Intervention	Multiple Stocking and Multiple Harvesting of Carps
Key Features	It is basically polyculture of carps with modified frequencies in stocking and harvesting. The multiple stocking and multiple harvesting method increase the carrying capacity of a pond and thus the total production becomes higher per unit area. The farmers get cash return regularly from the pond after a short period of 4-5 months. The stock is replenished species-wise immediately after each harvest. This encourages farmers to reinvest the money for purchasing of inputs for continuing the farming. The key feature of this method is the full utilization of is all trophic and spatial niches of the pond throughout the culture period, and thereby maximizing the production. This allows smaller fish to grow faster. Higher stocking density of about 12,000/ha is maintained throughout the culture and fish culture is continuously done for 3 years at a stretch.
Geographical Spread of Demonstration	15 districts of Assam; namely Kokrajhar, Dhubri, Barpeta, Nalbari, Goalpara, Jorhat, Morigaon, Lakhimpur, Dhubri, Darrang, Sonitpur, Nagaon, Golaghat, Sivasagar and Cachar (planned for demonstration)
Adaptation Hypothesis	Multiple stocking and multiple harvesting of carps helps in maintaining the constant and higher carrying capacity of the pond and improves the profitability and financial liquidity of the farmers through higher production and income at regular intervals. This in turn enhances the adaptive capacity of the farmers against the impacts of climatic change.
Adaptation Benefits	1. Farmers need not require big capital to meet the recurring expenditure. Farmers have to manage the pond for a maximum period of 4 months. Then onwards, farmer starts earning, which is reinvested for purchasing inputs. 2. Netting in short intervals results in release of abnoxious gases and mixing of bottom nutrients with surface water. This enhances the primary productivity of the pond.

		3. Small and marginal farmers can take up this with limited capital.
Production Results		Fish production is 6.0 to 6.5 t/ha^{-1}yr^{-1} (average of three years)
Driving Forces		Easy for small and marginal farmers as they need not to go for dewatering and pond preparation every year. Farmers get income at short interval regularly. Suitable for large perennial ponds. Even if flood water submerges the pond, the loss is partial due to multiple harvesting practice.
Restraining Forces		Need the supply of stocking material throughout the year.
Actors Involved		Fish Farmers, Input Suppliers and Traders
Sustainability		High. Enables sustainable increase in aquaculture production without adverse socio-economic or environmental impacts.
Replicability		High. This system of farming is suitable for large ponds where annual dewatering for pond is cumbersome.
Over-arching Impact	Economic	Increase in income, provides diversified products, continuous cash flow
	Social	Nutritional security for local community, greater dietary diversity
	Ecological	No adverse impact on soil and water quality when managed scientifically.
Institutional Mechanism		Institutional arrangements between farmers, DoF, WorldFish and ARIAS Society facilitate the better adoption of the technology.
Leanings		Mesh size of the harvest net should be such that fishes less than 250g can easily escape. To get high production, it is important to maintain a fine balance between total fish biomass and carrying capacity of the pond. Efficient use of supplementary feed is crucial. Need for seed rearing space to produce seeds required for multiple stocking Net profit is more than fish culture of single stocking and single/multiple harvest cycle.

5.1.6 Polyculture of Carps along with Mola and other Small Indigenous Species (SIS)

Name of the Intervention	Polyculture of Carps along with Mola and other Small Indigenous Species (SIS)
Key Features	In India, the commercialization of fish farming initially made inroads through composite fish culture of carps. Here, the focus was to grow only the fast-growing species of carps at the expense of other species. The small Indigenous Species (SIS) were the victims of this system and referred to as 'trash' or 'weed' fish. SIS got eliminated systematically during pond preparation either by dewatering the pond or by application of piscicides. This is considered as one of the major reasons for the sharp decline in availability and biodiversity of SIS. This has led to the change in perception towards SIS over the years and they are now seen as nutritionally valuable species. Moreover, they are found to have high nutritional value in terms of both protein content and the presence of micro-nutrients, vitamins and minerals. Unlike carps, SIS are eaten whole with head, bones and other organs. This is another reason for SIS to provide rich source of micronutrients for human. SIS are now referred as micronutrient-dense fish species instead of trash/weed fish. This transformation has invoked interest in commercial farming of SIS. The polyculture of carps and SIS in pond culture system is viewed as a potent strategy to augment the production of SIS and in turn a means to combat micronutrient deficiencies in women and children. Now it is a globally acknowledged as nutrition sensitive aquaculture concept and gaining popularity. It is pertinent to mention that the World Food Prize 2021 was conferred on Dr. Shakuntala Haraksingh Thilsted of WorldFish in recognition of promoting nutrition-sensitive approaches to aquatic food system through SIS. Dr. Shakuntala is one of the key experts in the ongoing APART project. Amongst SIS, mola is one of the most preferred species. It tastes good and is easy to process as it is devoid of scales.
Geographical Spread of Demonstration	11 Districts of Assam.
Adaptation Hypothesis	Culture of SIS with carps will enhance the production of SIS and in turn will increase the intake of micronutrient-dense SIS by local population. In local context, this will help in combating micronutrient deficiencies among women and children in Assam. It will make the pond aquaculture system more resilient.
Adaptation Benefits	1. Farmers get additional income from aquaculture in the form of SIS.

		2. It aids to the nutritional security of the vulnerable population of women and children. 3. As the larger carp species are not eaten whole, their nutritive value remains relatively low. On the other hand, small indigenous species are cooked and eaten whole with head, bones and other organs. Therefore, these species provide a rich source of micronutrients.
Production Results		Carp production was not hampered with the inclusion of SIS like mola. There was additional production of mola which the households consumed through regular partial harvesting. Even, the excess mola was sold resulting in additional income for the farmers.
Driving Forces		Mola thrives and grows well in polyculture system. Being a self-recruiting species, it matures and breeds in the pond. Therefore, once the population is established in the pond, it gives sustained production. The domesticated stock can also be used for further stocking.
Restraining Forces		Lack of commercially viable induced breeding and nursery technology for mola and SIS result in limited supply of stocking material at present. Mola is a delicate species and needs careful handling during harvest and live transport.
Actors Involved		Fish Farmers, Suppliers of live mola as stocking material and Traders
Sustainability		High. Mola is self-recruiting and compatible with carps in pond culture without adverse socio-economic or environmental impacts.
Replicability		High. Polyculture of mola and SIS with carp can be taken up in ponds of any size and type; *i.e.,* small and large ponds, as well as perennial and seasonal ponds.
Over-arching Impact	Economic	Increase in income, provides diversified products
	Social	Nutritional security for local community, greater dietary diversity. Combat micronutrient deficiencies among women and children.
	Ecological	No adverse impact on soil, water quality and pond ecosystem whatsoever.
Institutional Mechanism		Institutional arrangements between farmers, DoF, WorldFish and ARIAS Society facilitate the better adoption of the technology.
Learnings		SIS an integral part of the everyday diet of the rural population of Assam, being consumed at high frequency in small amounts. Hands-on training to farmers on production, harvesting and supply of brood stock of mola and SIS to new farmers are

	crucial for wider propagation. Use of soft net, separation of mola from large fish using grader net, application of tools useful to reduce the stress on mola during handling are important. Need to incorporate mola broodfish in the fish seed supply chain.

5.1.7 Polyculture of Carps with Freshwater Prawn

Name of the Intervention	Polyculture of Carps with Freshwater Prawn
Key Features	Freshwater Prawn (*Macrobrachium rosenbergii*) is a high value candidate species for aquaculture. The benthophagic omnivore feeding habit makes the prawn a good candidate species for polyculture and it goes well with carps. Prawn being a bottom feeder, the stocking of bottom feeding species like mrigal and common carp should be avoided in polyculture. Species like catla, rohu, silver carp and grass carp are compatible with freshwater prawn. Moreover, unlike brackishwater shrimps, the freshwater prawns are self-limiting in respect to total production due to antagonistic interaction amongst themselves. This justifies the need for polyculture with carps instead of monoculture to maximize the pond efficiency and profitability. The cannibalistic and territorial instincts of prawns necessitate low stocking density and also the provision of hiding arrangement in pond for better survival rate. The presence of fish in a polyculture system serves as a biological control over development of zooplankton, phytoplankton and filamentous algae, which otherwise result in ecological instability of the pond ecosystem. On the other hand, freshwater prawn under polyculture with fish derives its partial nutrition by utilizing the natural pond productivity and left-over fish feed, faecal matter of fish, etc. Moreover, this can be a good option especially for the land locked states like Assam for increasing the income of farmers through high value freshwater prawns produced and made available in domestic markets.
Geographical Spread of Demonstration	Kamrup, Nalbari and Goalpara Districts
Adaptation Hypothesis	Inclusion of high value species of freshwater prawn in carp polyculture will enhance the farm profitability. The financially sound farmers will have better adaptive capacity against the impacts of climatic change.
Adaptation Benefits	1. Farmers get additional income from polyculture of carps along with high value freshwater prawn. 2. It has excellent demand and fetches premium price at local market.

		3. If the production is ramped up, it can be exported and the state will earn foreign exchange.
Production Results		Under technical supervision, the production rate is 4500 kg fish and 400-500 kg freshwater prawn/ha/yr.
Driving Forces		Freshwater prawn thrives and grows well in polyculture system. Good market demand and fetches premium price. Profitable activity Good enthusiasm amongst farmers towards the freshwater prawn polyculture with carps
Restraining Forces		Scanty availiabilty of freshwater prawn juveniles from the wild in Assam Lack of commercial freshwater prawn hatchery in the state High operational expense
Actors Involved		Fish Farmers, Freshwater prawn seed suppliers and Traders
Sustainability		High. Freshwater prawn is compatible with carps in pond culture without adverse environmental impacts. The activity has good socio-economic acceptance.
Replicability		High. Polyculture of Freshwater prawn with carp can be taken up in ponds located at suitable areas.
Over-arching Impact	Economic	Increase in income, provides high value product
	Social	Aids to social wellbeing of local community
	Ecological	No adverse impact on soil, water quality and pond ecosystem in polyculture system
Institutional Mechanism		Institutional arrangements between farmers, DoF, CoF, WorldFish, ARIAS Society and CIFA facilitate the better adoption of the technology.
Leanings		Partial harvesting of marketable size prawn at regular interval is better than one-time harvest. This improves survival rate and facilitate the growth of small size prawn. Unlike fish, prawn is nocturnal. Therefore, pawn feed must be applied in evening and night hours, preferably in trays. Hiding arrangements such as pipe, hollow bamboo, betel nut leaves, coconut leaves, tyres, tree branches, etc. should be provided in the pond for better survival of prawn. Training and hand holding support to the farmers are crucial for the success.

5.1.8 Cage culture in *Beels* for raising fingerlings and table fish

Name of the Intervention	Cage culture in *Beels* for raising fingerlings and table fish
Key Features	Cage is an enclosure, which can be of any shape or size wherein the raising of fry to fingerlings and fingerlings to table size is being practiced in large open water bodies. Though the cage is more suitable for large reservoirs, same can be also used effectively in *beels* for raising fingerlings and table fish. Cages must be installed in deeper areas of the *beel*. The depth of the water column should be at least 3 m. For cage installation, water quality and circulation should be good, free from local and industrial pollution. The size of a cage may vary based on requirement. A standard size of 4 m X 2 m X 1.5 m (L x B x D) rectangular GI / bamboo Cages with HDPE net and nylon ropes are suitable for the *beels* of Assam. Fixed cages are more suitable for a water depth of 3-4 m and for a water depth of 5 m and more, floating cages are preferred. Indian major carps, Exotic carps, Minor carps and air-breathing fishes are suited for cage culture. Stocking density depends on the species and size of the fish to be stocked. Supplementary feed is invariably given to enhance the growth of the fish.
Geographical Spread of Demonstration	This on-going demonstration is taken up by COF during 2020-21 in 7 *beels*.
Adaptation Hypothesis	Use of cage for raising fingerling and table fish in *beels* ensures the timely supply of quality stocking material and significantly contributes to the production enhancement. In the event of flood and other climatic hazards, the stocks in the cage remain protected.
Adaptation Benefits	Useful method for in-situ raising fry to fingerling as stocking material for *beels* and also for raising table-size fish. Enhances the overall fish production of the *beel*.
Production Results	Harvesting is done in every 45 days interval in carp seed raising practice. In 45 days of time period, 2.0-4.0 cm carp fry grows up to 9.0-19.0 cm depending on the species with the stocking density of 250 nos./m3.
Driving Forces	Contributes to enhance the overall fish production of the *beel*. Easy harvesting and almost without any cost.
Restraining Forces	Not suitable for the places where the depth of the water column is less than 3 m.

Actors Involved		Fishermen, Cage Fabricators and Traders
Sustainability		Moderate. Cage culture is compatible with *beel* ecosystem without any adverse socio-economic or environmental impacts, if managed properly.
Replicability		Moderate. Popular amongst the fishermen as well as the lessees of the *beels* as a method to enhance the productivity.
Over-arching Impact	Economic	Contributes to productivity enhancement of *beels*.
	Social	Aids to social wellbeing of local community
	Ecological	No major adverse impact on soil, water quality and *beel* ecosystem
Institutional Mechanism		Institutional arrangements between *beel* management committee, CoF, DoF, WorldFish, ARIAS Society, CIFRI and NFDB will facilitate the better adoption of the technology.
Learnings		Active involvement of *beel*-dependent communities in the management of cage is crucial. Cage installation sites should be in sheltered areas for the protection from strong winds. Further, site should be safe from human interference and grazing animals. The site should have good social environment, *i.e.,* areas having low poaching problem. Cages should be cleaned fortnightly to remove algae and other debris and organisms. Loose twine, mesh torn by predators, anchors and sinkers should be checked routinely and immediately mended or replaced as needed.

5.1.9 Production improvement in *Beel* through fish stock enhancement

Name of the Intervention	**Production improvement in *Beel* through fish stock enhancement**
Key Features	Production improvement in *Beel* covers a wide range of practices. They are often adopted in a stepwise manner leading to a sustainable increase in fish production per unit area through increasing human control on parameters governing fish assemblages. Among the various fisheries enhancement techniques, fish stock enhancement (i.e., supplementary stocking with fingerlings of economically important fast-growing species like the Indian major carps) to utilize all the available food niches is an effective management tool to increase fish yield from the *beels* of Assam. Fish stock enhancement is a very simple and low-

		cost management tool for increasing fish yield rates from *beels*. It is an economically viable management option for *beels* since there is no use of supplementary feed or fertilizer. This option causes minimum environmental damage to the *beel* ecosystem. Fish seed released into the *beel* ecosystem grow fast with high survival rate because of large water-spread area and varied natural foods available there. Stocking of fingerling (15-20 cm size) was found to be most suitable for stock enhancement programs in the beels of Assam in terms of survival rate (>80%). The benefits of stock enhancement in *beels* are shared by the *beel*-dependent fisherman community unlike in pond aquaculture where the benefit reaches a few individuals.
Geographical Spread of Demonstration		This on-going demonstration is being taken up by Department of Fisheries in selected *beels* during 2020-21
Adaptation Hypothesis		Fish stock enhancement through selective stocking of commercially important fast-growing fish species will help in increasing the fish production of *beels* by utilizing the unused trophic and spatial niches of the ecosystem efficiently. It will also compensate for disruption of recruitment of commercially important major fish species from the parent rivers in closed and seasonally open *beels*.
Adaptation Benefits		Enhances the overall fish production of the *beel*. Helps in improving the socio-economic condition of the *beel*-dependent community.
Production Results		Optimal stocking density estimated for *beels* of Assam is 3,000 fingerlings/ha for closed *beels* and 3,600 fingerlings /ha for seasonally open *beels*. Fish yield rates in *beels* under fish stock enhancement programme generally range from 1-2 t/ha. /yr. depending on the size, type and the management regime of the *beel*.
Driving Forces		Very simple and low-cost intervention (involving only supplementary seed stocking)
Restraining Forces		Difficulties in procurement of stocking material of appropriate size at right time, unless raised *in-situ*.
Actors Involved		Fishermen, Seed suppliers and Traders
Sustainability		High. Compatible with *beel* ecosystem without any adverse socio-economic or environmental impacts, if managed properly.
Replicability		High. Widely adopted method to enhance the productivity of *beels*.
	Economic	Contributes to productivity enhancement of *beels*.
	Social	Aids to social wellbeing of local community

Over-arching Impact	Ecological	No major adverse impact on the biodiversity and ecosystem of the *beel*
Institutional Mechanism		Institutional arrangements between *beel* management committee, DOF, WorldFish, ARIAS Society, CIFRI and NFDB will facilitate the better adoption of the technology.
Learnings		Involvement of *beel*-dependent communities in the fish stock enhancement activity is crucial. Bath treatment of seed with potassium permanganate @ 5 mg/l for 1-2 minutes before stocking in the *beel*. Instead of external fertilization, nutrients trapped in the *beel* sediments may be made available to the phytoplankton population through bottom raking. Stocking of small indigenous species is recommended if natural stock is less. Macrophytes that contribute to the *beel's* food web should be controlled (manually/mechanically) only when they adversely affect the *beel* ecosystem.

5.2 In-depth Study on Paddy-Fish Farming System in Assam

Rice and fish are staple diets for the people of Assam and they are grown almost in all agro-climatic regions of the state. The geo-climatic variations and agriculture's dependence on rainfall have resulted in three distinct paddy growing seasons in Assam; *Sali* or winter paddy (June/July to November/December); *Ahu* or autumn paddy (March/April to June/July); and *Boro* or summer paddy (November/December to May/June). The traditional practice of raising fish in the paddy fields probably began with the beginning of paddy cultivation itself in the North East, because the waterlogged paddy fields create a natural habitat for fish. However, over the years the practice has evolved with recognition of its multi-ecological benefits. In India, apart from North-East states, it is also practised in a traditional way in the coastal states of Kerala and West Bengal. In Assam, the nature and type of integration vary largely depending upon the topography of land and other contexts which are based on biophysical and technical considerations. Though paddy field fisheries is recognised as traditional practice in the region, of late it is deliberately seen as a productive fishery, their provision of food and nutrition security, the cultural appreciation of wild sourced foods, and as alternate to high input based commercial aquaculture. It is an extensive level of farming practice using low input technology. The cost and return evaluation showed that paddy-fish integrated farming is more profitable than monoculture of paddy.

In paddy-fish integration, creation of fish refuge is an essential feature. Fish refuge is a deeper area provided for the fish within the paddy field. This can be in the form of a trench or several trenches, a pond or even just a pit. The purpose of the refuge is to provide a place for the fish in case water in the field dries up or is not deep enough. It also serves to facilitate fish harvest at the end of the paddy season, or to contain fish for further culture whilst the paddy is cultivated. In conjunction with the refuge, provisions are often made to provide the fish with better access to the paddy field for feeding.

In Assam, paddy-fish integration is mostly practised in flooded river basins, unmanageable vast waterlogged area and perennial waterlogged wet paddy lands. The practice is prevalent in the districts of Lakhimpur, Dhemaji, Darang, Sonitpur, Kamrup, Barpeta, Nalbari, Dhuburi and Jorhat where fishes enter into the paddy fields during monsoon and grow along with paddy. Fishing activities start after the recession of water during November-December and the farmers use various fishing gears like cast nets, gill nets, lift nets, indigenous traps either operated in the paddy-free spots of the field or are fixed at appropriate water entry and exit points in the fields. These lands often remain dry from December to April. Physically, the aquatic phase starts from May to November and possesses varying water depth depending on land topography, local rainfall patterns, water tables, soil quality etc. In aquatic phase, it becomes a rich and productive biological system for fish farming.

The paddy-fish integration in Assam can broadly be classified into three categories: (i) Perennial System of Paddy-Fish Farming, (ii) Synchronous Refuge Pond System of Paddy-Fish Farming, and (iii) Enclosure System of Paddy-Fish Farming. In perennial paddy fish farming system, a single crop of fish is raised along with two crops of paddy viz. *Ahu* (autumn paddy) & *Sali* (Kharif-Winter paddy) covering nearly both the seasons. The system is particularly suitable for very low-lying areas. Excavation of a big pond or a trench and construction of a perimeter dyke both covering around one-third of the total plot area are distinctive features under this system. In Synchronous Refuge Pond system of Paddy-Fish farming, the fish crop is raised synchronously with *Sali* paddy during the monsoon period. The plots are so prepared that fish can take shelter in the pond within the plot. Medium low lying with poor drainage areas are selected for this system. Plots having naturally existing small ponds can be efficiently brought under this system. In Enclosure system of Paddy-Fish farming, the fish crop is raised with deep water paddy (*Bao*) in deep water areas by enclosing the plot with pegged screens. Typical deep water paddy growing areas are selected where water level remains 1.5 m during the paddy cultivation period. The height of the

screen is kept at least 1m above the highest flood level. Bamboo is the widely used material for preparation of enclosing screen. Apart from these, the homestead ponds can be connected to nearby paddy fields to bring the area under paddy-fish system with the participation of women. The wetlands can be also brought under semi-closed seasonal paddy-fish system with the participation of the local communities. In Assam, submergence-tolerant paddy varieties assume greater importance in view of the recurring damages caused by floods.

In APART project, WorldFish and IRRI (International Rice Research Institute) are working together to improvise the traditional Paddy-fish culture system through multi-locational demonstrations at farmers' field with the objectives of introducing climate resilient paddy-fish integrated farming for improving the livelihood, income and nutrition of smallholder farmers along with gender equitable employment. The important considerations are the species and density of fish, paddy varieties, water management and the use of agro-chemicals. BINA Dhan 11 is a high yielding medium duration (110-135 days) submergence tolerant variety suitable for Paddy-fish integration. It is grown both during Kharif and rabi seasons and can tolerate flooding up to two weeks.

In 2018-19, the demonstration covered an area of 41 ha with 91 beneficiaries, which increased to 100 ha with 206 beneficiaries and 289 ha with 570 beneficiaries for the year 2019-20 and 2020-21 respectively. The project has a target of scaling up the activities in 500 ha in phases. Based on the successful demonstration of paddy-fish integrated farming under APART project, Government of Assam is planning to promote the activity to bring the flood affected areas in Assam for the livelihood security of the farming communities. IRRI and WorldFish have already identified the areas suitable for Paddy-fish integration in Assam using GIS. It is expected to develop Paddy-fish integrated farming systems in Assam that could enhance the adaptability of food system to climate change.

5.2.1 Climate Resilient features of Paddy-fish culture

A recent study estimates that methane emission from paddy-fish cultivation system is 34.6 % less than that from the paddy monoculture system (Mansharamani *et. al,* 2020). Methane emission from paddy fields is due to anaerobic degradation of organic matters under submerged conditions where there is a lack of oxygen. In paddy-fish integration, fish disturb the soil layers by their movement and often in search of food, and thus they increase the dissolved oxygen in water. This shifts anaerobic digestion to aerobic digestion and thus helps to reduce methane emissions from paddy cultivation. Fish can

also be seen as bio-control agent as it is effective in control of mosquitoes and snails, and will favour integrated pest management plan for paddy. Fish often control weeds in paddy fields as well. Further, growing *Azolla* (is a genus of seven species of aquatic ferns, commonly referred as duckweed or water fern) together with fish and paddy will have added advantages. Apart from serving food for the fish, *Azolla* is also a good nitrogen source for the paddy because of its nitrogen-fixing capacity. An increase in paddy production to the extent of 5-15% has been recorded in paddy-fish integration. The fish excreta and the unconsumed fish feed act as manure for paddy.

In Assam, women are integral part of the farm labour force. Therefore, paddy-fish integration will expand women's participation further. The widespread adoption of paddy-fish farming will bring three macro-economic benefits for Assam, *i.e.,* nutritional security, employment generation, and income to improve the livelihood of the farmers in flood prone low-lying areas.

The integrated paddy-fish systems have the high reliability and stability and therefore better adapted to future changes. Paddy-fish systems are promising climate resilient models for the climate changes and challenges which will reduce risks for smallholders and maintain productivity and sustainability. For widespread adoption of paddy-fish culture in Assam, the concept should become part of the agricultural system rather than the fisheries system. For dissemination of the technology, the Agriculture Department, Assam Agriccultural University and IRRI should take the central role while the Fisheries Department and WorldFish should be in supporting role. The Agriculture Department should reach out to the paddy farmers with the package of practices while Fishery Department may pitch in to facilitate for the fishery component. Because, the paddy farmers have to be motivated to take up fish farming along with paddy, not the vice-versa.

Table 5.1 Comparison between different Rice-Fish Farming practices prevailing in Assam (modified from Package of Practices on Fisheries and Aquaculture, AAU, 2017)

Attributes	Perennial System	Synchronous Refuge Pond System	Enclosure System
Suitable site	Low lying fields with high rainfall and poor drainage	Medium low-lying area and poor drainage	Typical deep water rice growing areas where 1.5 m during the paddy

			cultivation period
Topography	Almost uniform contour, preferably flood free area	Plot with a pond or ditch	Preferably having uniform contour, Screen height is kept at least 1m above highest flood level
Configuration	Paddy plot, perimeter dyke, Trench / pond.	Paddy plot, perimeter dyke, pond	Fish is raised with paddy within the enclosure
Lay out	**Perimeter trench model**- trench is one-fifth of the plot area, depth of the trench is 1.2 m. **Lateral trench model**- two trenches are dug on the sloping lateral sides. **Central pond model**- Pond is excavated in the middle of the plot with no embankment in one-third area & with 1 m depth	Plot naturally having small pond, Common plot size: 0.05-0.1 ha. Pond in 20% area; minimum water depth in pond is 0.8 m.	No pond / trench is constructed. Places where water level remains 1.5 m during the paddy cultivation period are selected.
Suitable Paddy varieties	***Ahu* crop-** *Rangadoria, Fapori, Govind, Lachit and CH-63,* etc. **Sali crop-** *Pankaj, Manohar sali, Sial sali, Ranga sali, Gudumoni, Badshah bhog, Gejep Sali, Ranjit, Jalashree, Jalakunwari* etc.	*Pankaj, Manohar sali, Sial sali, Ranga sali, Gudumoni, Badshah bhog, Gejep Sali, Ranjit, Jalashree, Jalakunwari* etc.	Deep water paddy (*Bao*) *PJNB-95-2, PJNB-96-10, Negheri bao, Padmapani, Kekowa, Panikekowa, Rupohi, Maguri, Tara bao*
Suitable Fish Species * & fingerling stocking rate	IMC (Rohu, Catla and Mrigal), Silver carp, Common carp, Bata, Silver barb, Java barb, Magur, Koi, Shing,	IMC (Rohu, Catla and Mrigal), Silver carp, Common carp, etc. Fingerling	IMC (Rohu, Catla and Mrigal), Silver carp, Common carp

		Tengra and SIS like Mola etc. Fingerling stocking- 8,000/ha.	stocking - 10,000/ha.	Fingerling stocking- 8,000/ha.
Preparatory work for Fish culture		Pond / trench is cleared of aquatic weeds, predatory fishes and excess organic deposit. Liming and manuring are carried out.	Pond is cleared of aquatic weeds, predatory fishes and excess organic deposit. Liming and manuring are carried out.	Liming and manuring are carried out.
Supplementary feed		Mustard oil cake and rice polish at 1:1 ratio as and when required	Mustard oil cake and rice polish at 1:1 ratio as and when required	Mustard oil cake and rice polish at 1:1 ratio as and when required
Production	Paddy	3600-4000 kg.	2900 - 3000 kg	3500 - 3600 kg.
	Hay	4300-4600 kg.	4250 - 5000 kg.	2300 - 3500 kg.
	Fish	1400-1600 kg.	900 - 1000 kg.	700 - 800 kg.
Eco-nomics per ha. per yr.	Income-Paddy	₹ 60,000/-	₹ 46,000/-	₹ 39,000/-
	Income-Fish	₹ 1,68,000/-	₹ 1,20,000/-	₹ 96,000/-
	Total Income	₹ 2,28,000/-	₹ 1,66,000/-	₹ 1,35,000/-
	Profit	₹ 69,500/-	₹ 43,900/-	₹ 24,700/-
	% Profit to turnover	30.48	26.44	18.29

* Stocking of grass carp is avoided when there is rice crop, may be stocked after paddy harvest. Common carp should be stocked after 15-20 days of rice transplantation

5.2.2 Grass Carp in Paddy-fish integrated farming

In above mentioned types of paddy-fish integration, the herbivorous fish like grass carp is generally avoided as it is believed that the grass carp feed on paddy plant and damage the paddy crop. But some farmers consider grass carp as a beneficial species in paddy-fish integration. To facilitate the inclusion of grass carps, two types of integration approaches are followed, *i.e.*, rotation and relay systems. In rotation system, immediately after paddy harvest, paddy field is flooded and advanced grass carp fingerlings collected from the nursery pond are released into the paddy field. The grass carp grow well by feeding on the left-out paddy stalk. In relay system, small size

fingerlings of grass carp are released one month after paddy transplantation. At that stage paddy plants are quite strong and small fingerlings don't do much harm to paddy plant. For about three months, paddy and fish grow together. After the paddy harvest, the fish grow fast by eating the plant residue of the paddy and by occupying larger space. As paddy is harvested while water in the field, only the top portion of the plant is cut and the large portion which remains inside water act as excellent food for the grass carp. Amur carp also goes very well in paddy-fish integration.

There are instances where the farmers sacrifice a portion of paddy plants for feeding grass carps as the income from the grass carp outweigh the loss from the paddy. Here, the chopped paddy plant is fed to fish. However, this may not be the prudent approach from the point of food security. Instead, those farmers can be motivated to grow green fodder like hybrid napier, para grass etc. on the dyke/embankment of the rice-fish fields that can be used efficiently to feed grass carp. There are certain paddy fields having gradual elevation, especially the land surrounding the wetlands. In these plots, farmers transplant different varieties of paddy at different time intervals. Initially when water inundates the lower region, deep water or submergence tolerant paddy varieties are transplanted. Then slowly when water inundates the upper region, normal paddy varieties are transplanted. Here the paddy cultivation goes for extended period and fish farming is synchronized accordingly.

5.2.3 Mola-SIS promotion in Paddy-Fish Integration

Traditionally, the waterlogged paddy fields were one of the most common fishing grounds for small fishes for the rural people of the region during wet/Kharif season (June to November). Hence, the paddy fields were the major source of SIS production and were contributing to the household nutrition in rural areas. Over the years, the Small Indigenous Species (SIS) of fishes which were once abundant in rice field, declined drastically with the adoption of yield yielding paddy varieties which involve liberal use of chemical fertilizers and pesticides. Therefore, under the APART project, an intervention on paddy-SIS integration was launched to revive this practice with scientific management. The objectives of the intervention are to increase the availability and accessibility of the micronutrient rich small fishes, and in turn to increase their consumption for nutritional security of farming communities. The commonly encountered species in paddy fields are *Ambhyopharyngodon mola, Ailia coila, Anabas testudineus, Chanda nama, Channa gachua, Channa marulias, Channa punctatus, Channa striatus, Chela cachius, Clarias batracus, Colisa labiosus, Esomus danricus, Glossogobius guiris, Heteropneustes fossilis, Labeo bata, Mastacembalus armatus, Mastacembalus*

pancalus, Mystus cavasius, Mystus julio, Mystus vittatus, Nandus nandus, Ompok pabo, Puntius chola, Puntius conchonius, Puntius sophore, Pethia ticto, Rasbora daniconius, Rasbosa rasbora, etc. However, in this intervention emphasis was given to include mola-SIS with carp in paddy-fish integrated farming demonstrations. WorldFish has developed this technology successfully and was adopted by large numbers of farmers in Bangladesh. Same is being replicated in Assam. Mola is found to be resilient in polyculture with carps even in paddy-fish integration. The production system increased the production of other SIS also, but the contribution of mola was the highest. Broodfish of mola collected from available sources (ponds, *beels* and wetlands) were introduced into the pond aquaculture system and over the time, its population got established. Carp-mola polyculture ponds could be a good source for stocking of mola in paddy-fish integrated farming system. This is because of proper management of ponds with supplementary feeding and fertilization, mola in these ponds are stronger and turn harder during regular netting of ponds.

5.2.4 Seed Rearing in Paddy-Fish Integration

Paddy-fish integration can be modified to meet the specific needs of the farmers or the region to make the farming system more resilient. Integrating fish seed rearing in paddy fields is one of them. Here instead of table-size fish production, emphasis is given for the use of paddy fields for raising fish fingerlings which in turn serve as stocking material for fish production in ponds and *beels*. Though relatively a new activity in Assam, the practice has been established in the Bangladesh with promising results, which is worth promoting in Assam.

6 Case Studies

Case Study 1

6.1 *Paddy-Fish Integrated Farming: Turning a Problem into Opportunity*

Name of the Beneficiary: Mr. Saheb Ali

(Member of Apollo Fish Producer Group on paddy-cum-Fish integrated farming under APART)

Address: Village: Barnibari, Block: Pachim Barnibari, District: Nalbari, Assam

Phone No.: 9957643559

Age: 36 yrs.

Number of family members: Total 5 (Self, wife and 3 sons)

Resources: Low-lying agricultural land of 10 *Bigha* (1.3 ha).

About the Intervention: The intervention is about conversion of the low-lying agricultural land for year-round paddy-fish integrated farming

Situation before Intervention: In *Sali (kharif)* season, the land was remaining fallow due to water logging and infested with water-hyacinth and some wild fishes. In *Boro* (*Rabi)* season, the land was used for paddy cultivation. The land was giving a meager annual income of Rs. 30,000-40,000/- with 600-800 kg paddy and 100-150 kg of fish (mainly the small indigenous fishes).

What happened under APART?

- Under the APART project, during the year 2019-20 total 18 beneficiaries of the locality were selected for paddy-cum-fish integrated farming as a climate resilient activity and Mr. Saheb Ali was one of them. Under the scheme, each beneficiary was given financial assistance (80% of the unit cost as subsidy) to bring 0.4 ha. area under paddy-cum-fish farming. However, farmers were free to develop more areas with their fund. Under this scheme, Mr. Saheb Ali converted his 10 *bigha* (1.3 ha.) agricultural land into paddy-cum-fish farming.
- The peripheral dike of around the land was raised by 1½ feet to withstand flood conditions and can give full protection to the fish crop. Provision of

guarded outlet through the dyke at different levels was kept to maintain desired water level in the paddy plot.

- The lower portion of 5 *bigha* (0.65 ha) was earmarked for paddy-fish farming. The upper portion of 5 *bigha* (0.65 ha) was left mainly for paddy cultivation during *Boro* season and was used for fish for rest of the period. Overall, 60% land was used for paddy cultivation and remaining 40% land was used for fish culture.
- A perimeter trench of 1.2 m deep and 3 m wide was dug parallel to the peripheral dike in the lower portion of 5 *bigha* land. The trench occupied an area of about 2.5 *bigha* (0.325 ha) and the remaining area of 2.5 *bigha* (0.325 ha) at center was used as open run for fish.
- Peripheral dike was used for planting horticultural crops like banana and lemon.

What motivated him for the intervention?

During *Sali* season, the land was remaining fallow with some wild fish growing and the farmer was not making enough earnings from the land through single cropping of paddy in *Boro* season. When the APART project staff approached the farmers like him in the village with the suggestion to convert the low-lying lands into paddy-cum-fish farming, they agreed. He had earlier also heard about the benefits of paddy-fish farming being undertaken scientifically elsewhere. The assurance of financial and technical help from the project further attracted him towards the proposed intervention as he felt that these will add to his production from the land and will boost his income.

What support he received from APART Project?

The farmer was briefed about paddy-fish integrated farming by the expert of the project. He also received training on this subject from the project. Leaflet in local language on the Better Management Practices of paddy-fish integrated farming was shared with him. He received critical inputs like fish seeds and feed from the project. Periodical visits were conducted by the project staff to extend technical support and to monitor the progress.

How he has done?

Farmer stocked fingerlings of 3-5 inch size (IMC, silver carp, common carp) in May after procuring from the local supplier. Before that, the trench area was cleaned properly followed by bottom mud removal, liming and manuring. The seeds of other species like bata, gonius, Chinese puthi, mola (breeder), etc. were released as and when available. Farmer stocked around 30 kg of seeds counting about 10,000 nos., excluding the small indigenous species. He also released grass carps of 100-150 g size after the harvest of paddy. The fishes

grew fast by eating the plant residue of the paddy and by occupying larger space. As paddy was harvested while water was in the field, only the top portion of the plant was cut and the large portion which remained inside water used as an excellent feed for the grass carp to grow up to 1-1.5 kg in 7 months. Liming and manuring were done at regular intervals during the culture. To achieve faster growth, supplementary feeds comprising of mustard oil cake, rice polish and floating pellet feed were given. Farmer harvested the fish periodically. First harvest started in August, while the complete and final harvest took place in January during *Magh Bihu* festival (which falls on 14th January). During that period, the harvested fish fetched premium price. The farmer harvested around 10-12 times during the period from August to January, and in each harvest caught 150-200 kg carps and 30-40 kg *mola* and other small indigenous species.

The farmer started plot preparation for *Boro* paddy in late January (after *Magh Bihu*) by ploughing 3 times and then manuring. First seed bed was developed and then transplanting of paddy seedlings was done after 20-25 days of sowing in late February. Farmer cultivated two varieties of paddy, *i.e., Swarna Masori* in upland and *Lal Ganga* in lowland part of the plot. *Swarna Masori* is a lightweight paddy with medium grain and fetches premium price. *Lal Ganga* is a deep-water variety with tall plant and grows well even in water logging conditions. Farmer harvested paddy in late May, after 3 months of transplanting and got good yield of 1200 kg/*bigha*. Bore well water was used for irrigating the paddy field. Same water was also used for fish farming in dry season. Whenever adverse conditions like lowering of water level, gas formation in the bottom sediments, oxygen depletion, etc. were encountered, bore well water was used either to fill or exchange water. By integrating paddy with fish, the farmer was able to reduce the feed cost as fish collected partial food from paddy field in the form of insects and other larvae. Grass carp grazed voraciously on the paddy straw, leftover after harvest. The farmer observed good growth of fishes when integrated with paddy than that of fish culture alone.

Land shaping work for paddy-fish integration

View of the plot with beneficiary in *Sali* season

Expenditure and Return details:

The economics of paddy-cum-fish farming as reported by the farmer from his 10 bigha (1.3 ha) plot in a year, where Paddy was cultivated in area of around 5 bigha (0.65 ha), 2.5 bigha (0.325 ha) trench area and 2.5 bigha (0.325 ha) open run area.

Table 6.1 Economics of paddy-cum-fish farming as reported by the farmer

Component	Item	Quantity (kg)	Rate (Rs)	Amount (Rs)
I. Fish				
A. Expenditure	Seed	50	500/kg	25000/-
	Lime	310	15/kg	4650/-
	Fertilizer (cow dung)	5400	0.64/kg	3000/-
	Feed			
	Master Oil Cake	2000	30/kg	60000/-
	Rice Polish	3000	20/kg	60000/-
	Pellet Feed	600	40/kg	24000/-
	Harvesting	25 times	1200	30000/-
	Marketing	25 times	600	15000/-
			Total	**221650/-**
B. Production	Carps	2500	150	375000/-
	Mola & other fish	300	200	60000/-
			Total	**435000/-**

C. Net Return	(A-B)			**213350/-**
II. Paddy				
A. Expenditure	Nursery Bed			
	Seed	5	480	2400/-
	Ploughing	L. S.	-	500/-
	Labour	L. S.		600/-
	Fertilizer	L. S.		400/-
	Seedling removal	L. S.		4500/-
	Transplanting	L. S.		4500/-
	Main Field			
	Ploughing	L. S.		4000/-
	Ridge construction	L. S.		2000/-
	Cow dung	1500		500/-
	DAP	50	30	1500/-
	Urea	50	15	750/-
	MOC	400	30	12000/-
	Potash	15	30	450/-
	Weeding	3 times		3000/-
	Thrashing & cleaning	L. S.		2000/-
	Marketing	L. S.		1500/-
			Total	**40600/-**
B. Production	Paddy	6000	12	72000/-
	Hay	L. S.		10000/-
			Total	**82000/-**
C. Net Return	(A-B)			**42400/-**
Total Expense	(I. A + II. A)	(221650/- + 40600/-)		**262250/-**
Total Income	(I. B + II. B)	(435000/- + 82000/-)		**517000/-**
Total Net Return	(I. C + II. C)	(213350/- + 42400/-)		**255750/-**

Cost Effectiveness:

The intervention was very cost effective. The level of profit to the turnover was 49.47%, which is quite high. The contribution of fish to the net return was 83.42 %, while that of Paddy was 16. 58 %.

Outcome:

The real and potential impacts of paddy-fish integration in terms of improved income and nutrition were significant. Integrating paddy with fish helped in generating additional income from the farm through better utilization of space, resources and time. It enhanced the adaptive capacity of the farmer in the light of current and future climate change impacts. It can be used as an effective tool for poverty alleviation in rural Assam.

Challenges faced:

- Modification of the paddy field to integrate fish farming was technically bit challenging. The real challenge was to provide deeper areas for the fish to grow without inundating the paddy plants and regulating the escape of fish and preventing access to the paddy field.
- The farmer received technical and financial support from APART project for making higher dykes, trenches and other facilities required for integration. However, for others, the high initial investment will be a restraining factor for widespread adoption of paddy-fish culture.

Learning:

- The selection of pesticides for application in paddy-fish field should be done judiciously as it may harm the fishes. However, paddy-fish farmers generally use less pesticide than that of paddy-only farmers as stocked fishes control the pests to some extent.
- The selection of stocking size and timing for stocking grass carp and common carp in paddy-fish system should be done carefully as they may cause damage to paddy plants by uprooting and eating them if not done sensibly.
- The paddy-fish integration is a boon for the low-lying areas and for the sites which are prone to frequent flooding. It can turn adversity into prosperity by creating an advantageous situation for the fish to grow to larger size and for longer duration.

Scope as Adaptation Strategy:

Paddy-fish integration is undoubtedly a potent strategy for adaptation to climate change especially in the flood prone areas of Assam. The departments of agriculture as well as fishery should jointly promote this activity as win-win strategy to enable economic gains and to address the climate change issues.

Way Forward & Scaling up:

Many farmers are aware of paddy-fish integration, but only a few realize the advantages. It should become part of public awareness so that the culture of fish in paddy fields of Assam becomes as integral to paddy growing as fertilizer application. In order to realize full potential, there is a need for a fundamental shift in attitude towards paddy-fish integration in all sectors involved, from policy-makers to extension officers and farmers. To scale up the paddy-fish activities across the state, it is necessary to strengthen the seed production and supply network, and to create scope for easy access to finance. Even if five to ten farmers of a locality take up this activity, it will make a visible impact for the sector.

Case Study 2

6.2 Carp Polyculture with Freshwater Prawn: Boosting Farm Income through High-value Species

Name of the Beneficiary: Mr. Sambhu Haloi

(Member of 'Sira Seuji' Fish Producer Group -FPG on carp polyculture with freshwater prawn under APART)

Address: Village: Khatkatara, Block: Pub Nalbari, District: Nalbari, Assam

Phone No.: 6001090350

Age: 43 yrs.

Number of family members: Total 5 (Self, wife, son, daughter and mother)

Resources: 8 ponds with total water spread area of 2.66 ha (20 Bigha) with piggery and goat rearing units on the dyke.

About the Intervention: The intervention is on inclusion of high value species of Freshwater Prawn (*Macrobrachium rosenbergii*) in carp polyculture. Freshwater Prawn being the bottom feeder, the stocking of bottom feeding species like mrigal and common carp are avoided.

Situation before Intervention: The farmer used to practice carp polyculture in modified extensive manner. He used to stock Indian major carps (Caltla, Rohu and Mrigal) and three species of exotic carps (Silver carp, Grass carp and Common carp). He was getting a modest production of 3.5 tonnes /ha. /yr. with a decent profit.

What happened under APART?

- In the year 2019-20, the APART project took up carp polyculture with freshwater prawn on pilot basis in the area by mobilizing 12 local fish farmers and Mr. Haloi was one of them. Under the scheme, each beneficiary was given financial assistance (80% of the unit cost as subsidy) to bring 0.25 ha. area under carp polyculture with freshwater prawn. Under this arrangement, Mr. Haloi stocked freshwater prawn along with carps in one of his ponds having area of 5 *bigha.*

- Through APART he received good quality prawn seeds of PL 20 size which he stocked in the pond after proper acclimatization. He also received critical inputs like sinking pellet feed, chemicals and probiotics from APART.
- The entire culture was conducted under the direct supervision of APART and WorldFish.

What motivated him for the intervention?

The area is known for fish farming and the farmers are also progressive. However, during the last few years, the production level from the ponds and the profit margin for the farmers had remained stagnant. Therefore, farmers were looking for an avenue to increase farm profit. As a solution to the problem, APART proposed the intervention with technical and financial support for culturing high value species of freshwater prawn with carps. Therefore, when the APART officials met Mr. Haloi and offered the choice, he just grabbed the opportunity.

What support he received from APART Project?

The farmer was educated on freshwater prawn culture with carps by the expert of the project through training. Lack of prawn seed is the major issue in propagating freshwater prawn farming in Assam. Therefore, APART made arrangements for the supply of freshwater prawn seeds, quality feed and other critical inputs at pond site. Periodical visits were conducted by the project staff who extended all kinds of technical support and also monitored the progress at regular intervals.

How he has done?

Mr. Haloi stocked his pond of 0.65 ha with 5000 carp fingerlings of 4-6 inch size (catla, rohu, silver carp and grass carp) in mid-July, 2020 after proper pond preparation. As advised, he didn't stock bottom dwelling species like mrigal and common carp. In September, 2020, he received 2000 prawn seeds of PL 20 size through APART project. After acclimatization, he stocked the seeds in a nursery tank for about one month and placed few branches of coconut tree inside which acted as shelter for the seeds. He fed the seeds with prawn starter feed. After one month, the prawn juveniles were transferred to the stocking pond and allowed to grow with carps. Prawns were fed daily at fixed places in the pond by broadcasting feed in the evening around 5-6 pm. Prawn being nocturnal, feed actively in night hours, while fish feed actively in day hours. For fishes, the farmer broadcasted feed in the morning hours. The pond biomass and water quality parameters were monitored regularly. There

was no incidence of diseases in fish as well as prawn. Farmer reported good survival and growth rate of fish and prawn.

Mr. Haloi displaying the size of the prawn being caught from his pond

Mr. Haloi with his family members at pond site

Expenditure and Return details:

Mr. Haloi could not provide exact expenditure and income details of the demonstration due to lack of proper record keeping. When visited the site on 6th Sept, 2021, the farmer reported to have already harvested around 2200 kg fish and around 20 kg of prawn. As per his estimate he is yet to get about 1200 kg of fish and about 40 kg of prawn from his pond. Therefore, the estimated total production from the pond of 0.65 ha is 3400 kg fish and 60 kg of prawn. The farmer was very much excited about the high sale price of the prawn. Farmer is selling the prawn of 120-150 gram size @ Rs. 1000/- per kg at Khagapar Wholesale fish market. The farmer reported to have incurred a total expenditure of about Rs. 3 lakhs and is expecting total income of about Rs. 6 lakhs by selling fish and prawn from the culture.

Cost Effectiveness:

From the angle of cost effectiveness, the demonstration scored high. The estimated level of profit to the turnover was 50%, which is quite promising. The contribution of prawn to the net return is 10 %, which is an additional income accrued to the farmer in the form of high value species.

Outcome:

The introduction of high value species like freshwater prawn in carp polyculture system proved beneficial for the farmers. Prawns thrived and grew well with carps in polyculture system. Prawn has very good demand and

fetched very high price in the market. Farmers are getting additional income through high value freshwater prawn. If the production is ramped up, prawn can be exported from the state after meeting local demand.

Challenges faced:

- The farmer received the prawn seed in late September. As winter set in after September in Assam, the prawns didn't get conducive climate to grow. Only after February, growth was visible in prawns. Therefore, early stocking of prawn in ponds, especially in the month of July and August, will boost the growth and production of prawns in ponds.
- The farmer received technical and financial support from APART project for undertaking prawn farming. However, for others, the high input cost towards the seed and feed will be a restraining factor towards widespread adoption of this technology.

Learning:

- Initial success in prawn farming has sparked great interest amongst the fish farmers of Assam. But major hurdle in large scale adoption of this farming is the lack of seed. Therefore, the interested farmers must make prior arrangements for procuring seed in time.
- The possibilities of setting up a freshwater prawn hatchery in Assam should be explored. It will go a long way in developing freshwater prawn farming in the state under monoculture and polyculture with carps.
- Training and hand holding support to the farmers on freshwater prawn farming are crucial for the success. Freshwater prawn farming involves some technical know-how which fish farmers generally lack.
- Partial harvesting of marketable size prawn at regular intervals is better than one-time harvest. This will improve the survival rate and facilitate the growth of small size prawn.
- Unlike fish, prawn is nocturnal. Therefore, prawns should be fed in the evening and night hours, preferably in trays. Prawns also require feed of high protein content as compared to fishes.
- Hide-out arrangements should be made by placing old pipes, hollow bamboos, old tyres, betel nut leaves, coconut leaves, tree branches, etc. in the pond bottom to serve as hide-outs for better survival of prawn.

Scope as Adaptation Strategy:

Freshwater prawn is compatible with carps in pond polyculture without adverse environmental impacts. Polyculture of Freshwater prawn with carp

can be taken up easily in ponds of Assam, provided freshwater prawn seeds are made available. Inclusion of high value species of freshwater prawn in carp polyculture will enhance the farm profitability. The financially sound farmers will have better adaptive capacity against the impacts of climatic change.

Way Forward & Scaling up:

The polyculture of carps with freshwater prawn technology is being demonstrated in Kamrup, Nalbari and Goalpara Districts. Therefore, the farmers of these districts are aware of the level of profit involved in it. But the major drawback in propagation of this technology is the lack of availability of freshwater prawn seeds locally. Even the farmers, who are currently doing prawn farming, are not sure whether they will be able to continue this next year as there is no certainty in getting the seed. To scale up the activity, it is necessary to establish and strengthen the prawn seed supply network and to make arrangements for easy and timely availability of seed for the interested farmers. Once the demand picks up, the state should take necessary steps in setting up freshwater prawn hatcheries in Assam to produce seeds locally.

Case Study 3

6.3 *Carp Polyculture with Mola-SIS: Promoting Nutrition-Smart Farming through Self-Recruiting Species*

Name of the Beneficiary: Mr. Dinesh Goswami (Member of Samannaya Fish Producer Group on carp polyculture with *mola* under APART)

Address: Village: Chengnoi, Block: Pub Nalbari, District: Nalbari, Assam

Phone No.: 9859080329

Age: 43 yrs.

Number of family members: Total 3 (Self, wife and daughter)

Resources: Ponds with total area of 4 ha. and a fish hatchery setup having one breeding pool and one hatching pool with a production capacity of 10 million spawn per cycle.

About the Intervention: The intervention is on scientific farming of small indigenous species (SIS) of mola (*Amblypharyngodon mola*) along with carps. Mola is considered as a species with high nutritional value in terms of both protein content and the presence of micro-nutrients like vitamins and minerals. Therefore, the intervention is viewed as a potent strategy to augment the production of mola-SIS to combat micronutrient deficiencies in women and children.

Situation before Intervention: Though mola-SIS is found in limited quantity in the ponds, due to lack of awareness, the farmers used to consider the species as 'trash' or 'weed' fish. Often Mola and other SIS are eliminated systematically during pond preparation either by dewatering the pond or by application of piscicides. This is the reason for the decline in availability of SIS in the ponds.

What happened under APART?

- Under the APART project, during the year 2019-20, a total of 125 beneficiaries from the locality (East Chengnoi and West Chengnoi) were selected for carp polyculture with mola-SIS as a climate resilient activity

and Mr. Dinesh Goswami was one of them. Under the scheme, each beneficiary was given financial assistance (80% of the unit cost as subsidy) to bring 0.25 to 0.35 ha. area under carp polyculture with mola-SIS.

- The WorldFish scientists from Bangladesh imparted hands-on training to the local farmers on production and harvesting of mola in carp pond. They also demonstrated the simple and low-cost harvesting technology for collection of brood stock from the pond and then supply live to the other farmers for wider propagation.
- The farmer initially stocked his pond (0.3 ha) with three to four kg of mola-SIS brood stock sourced from natural resources and from another pond. After 2 months, he started harvesting mola-SIS monthly from the pond.
- The farmer used soft net (grader net) of required mesh size to catch the brood stock of mola-SIS from his pond and supplied to neighbouring farmers as stocking material.

What motivated him for the intervention?

The farmer was motivated to take up scientific mola-SIS culture along with carp polyculture after attending the awareness camp where he was briefed on the feasibility of mola-SIS farming along with polyculture of carps. Subsequent hands-on training and the visit of expert from Bangladesh to his farm instilled confidence in him and invoked interest in commercial farming of mola-SIS along with carps.

What support he received from APART Project?

The farmer received hands-on training on this technology from the project. He received critical inputs like mola-SIS brood stock and feed from the project. Periodical visits were undertaken by the project staff to extend technical support and to monitor the progress.

How he has done?

Mr. Goswami stocked his pond of 0.25 ha with 2000 carp fingerlings of catla, rohu, and mrigal in July, 2020 after proper pond preparation. In the month of August, 2020, he stocked about 4 kg of mola-SIS brood fish (both male and female fish with average size of 2-3 inch) in phases after collecting from *beels* and the other ponds. The stocked mola-SIS started breeding after one month in the pond. Hence, he used his pond for carp polyculture with mola-SIS. He fed fishes with supplementary feed regularly and took care of the water quality

by liming the pond as and when required. By November, 2021; Mr. Goswami had already harvested about 875 kg of carps and 210 kg of mola-SIS from his pond. He used to harvest fish at regular interval in 2-3 months gap. By using fine meshed drag net, he used to harvest carps and mola at a time. In each harvest, he used to catch about 150-170 kg carps and 40-50 kg mola-SIS. He sells only adult mola as it fetches good price of Rs. 170-200/- per kg in the nearby wholesale market. Since mola is a delicate fish, it spoils fast after harvest. Therefore, to get premium price, he transports mola live soon after harvest to the wholesale market which is located at about 8-10 km distance from his village. During harvest, whatever mature mola brood fish are caught, half of it he releases back to the pond for breeding and rest he sells in live condition at pond site to the interested farmers as stocking material. The farmer opined that, regular harvesting of mola is very crucial to obtain good production from the pond. Since mola is a self-recruiting species in pond environment, periodical harvesting helps in controlling the stock at sustainable level. Otherwise, pond is be overpopulated with mola leading to poor growth and old stock die due to age.

Mr. Goswami harvesting mola from his pond

Beneficiaries from the village with a haul of harvested mola

Expenditure and Return details:

Mr. Goswami could share rough estimate on the expenditure and return obtained from the culture. He reported to have already harvested around 875 kg of carps and 210 kg of mola from the pond of 0.25 ha. On ha. basis, the production comes to 3500 kg of carps and 840 kg of mola which is quite good. The farmer incurred a total expenditure of about Rs. 0.95 lakh and got a total income of about Rs. 1.6 lakhs by selling bth carps and mola.

Cost Effectiveness:

The polyculture of carps with mola-SIS reported high in cost effectiveness. The level of profit to the turnover was 40%, which is encouraging. The contribution of mola-SIS to the net return is high, *i.e.,* about 30 %.

Outcome:

The culture of small indigenous species of mola-SIS with carps was a winning combination for the farmer. Mola thrived, bred and grew well in the pond. Mr. Goswami got good price for mola as he harvested only large size and has his own facility to transport the same without quality deterioration to nearby wholesale market. But the situation was different for other mola farmers of the village. They reported very low sale price of Rs. 40 to 50/- per kg for mola. Because, they engage outside fishermen to harvest fish who buy back mola from pond site at very low rate.

Challenges faced:

- As such, farmer didn't face any problem in the culture of mola. Traditionally, mola is found in the local ponds. But earlier the local farmers were ignorant of its nutritional value and were not growing mola in a proper manner. Through APART project, the farmer received hands-on training.
- The real challenges lie in marketing mola, especially for small farmers. Since it is a delicate fish and spoils fast, selling raw fish at market in good condition will not be easy.

Learning:

- SIS like mola with carp polyculture in homestead pond can improve access to nutritious small fish for family members, especially women and children.
- Use of soft net, separation of mola from large fish using grader net, application of tools useful to reduce the stress on mola during handling, etc. are the small techniques which are important for successful mola farming.
- In large fish, mainly the flesh is eaten, which has fewer micronutrients than in the whole fish. But due to the small size, mola is eaten whole, thereby consuming the eyes, head, bones and internal organs which are rich in minerals and vitamins.

Scope as Adaptation Strategy:

Mola is very much compatible and financially rewarding with carps in all types of ponds including the homestead ponds. The financially sound farmers will have better adaptive capacity against the impacts of climatic change.

Way Forward & Scaling up:

Carp-mola polyculture is a mainstream aquaculture activity in Bangladesh. WorldFish is now propagating the same technology in Indian states of Odisha and Assam. To make mola widely and easily available to the consumers, emphasis should be given on post-harvest processing and value addition. Value-added products like dry fish, fish pickle, etc. can be prepared easily involving women SHGs in the places closer to mola farming areas. Currently, the brood fish of mola are stocked in ponds for self-breeding and establishing the population. However, for large-scale commercial farming, there is a need for standardizing the technology for captive breeding and seed rearing.

Case Study 4

6.4 *Short Duration Fish Farming using stunted yearlings: Reducing flood-induced Risks and Reaping Profits*

Name of the Beneficiary: Mr. Abdul Hasen

Address: Village: Bhehuguri, Block: Bortordoya, District: Morigaon, Assam

Phone No.: 9577361474

Age: 55 yrs.

Number of family members: Total 13 (Self, wife, 3 sons, 3 daughters-in-law and 5 grandchildren)

Resources: Six fish ponds with total water spread area of 1.46 ha. (11 *Bigha*) and a fish hatchery of 10 million spawn per cycle capacity with one breeding pool and five circular hatching pools.

About the Demonstration: The demonstration was on short duration fish farming as climate resilient technology against flood-induced risk. The demonstration was conducted by College of Fisheries (AAU), Raha in 2019 at farmer's field under direct supervision of the Principal Investigator.

Situation before Intervention: Farmers of the area were engaged in conventional fish farming with stocking of fry or fingerling of Indian Major Carps and Exotic carps and culturing for about 10 months. Depending on the level of input use and management, farmers of the area got the production of 3000-4500 kg/ ha. But farmers face the risks of fish escape and crop loss in rainy season due to flood and excess rain.

What happened under APART?

- Under the APART project, in the year 2019-20 total 15 demonstrations were conducted in 15 districts of Assam and Mr. Abdul Hasen was chosen as the beneficiary in Morigaon district. He was given financial as well as technical assistance by the College of Fisheries for the demonstration. Two of his ponds (one of 1 *bigha* and another of 1.5 *bigha*) were brought under the short duration fish farming.

- Ponds were dewatered completely and the bottom was exposed to sunlight. While removing the bottom sediment, embankments and side slopes were repaired, followed by other pond preparation steps like ploughing, liming, manuring and water filling etc.
- The entire demonstration was conducted under the direct supervision of Prof. S. Borthakur, Department of Aquaculture, College of Fisheries (AAU), Raha.
- The farmer stocked stunted yearlings of catla, rohu, mrigal, grass carp, and bata (1500 in 1.5 *bigha pond and 1000 in 1 bigha pond).* The average size of the stocking material was 50-60g in weight and 4-5 inch in length. The number of rohu was more than the other species. The stunted yearlings were sourced from his own farm except some rohu fingerlings which he procured from a farmer of same village.

What motivated him for the intervention?

Mr. Hasen is a progressive fish farmer in his area. Along with farming, he is into the business of seed production and dealing with inputs like feed and aqua-medicines. Earlier he had heard about the success of carp farming in Andhra Pradesh where farmers stock stunted yearlings in ponds for growing big size fish with more yield. In 2019, when Prof. Borthakur met him and requested him to participate in the demonstration of short duration fish farming using stunted yearlings, he readily accepted the offer.

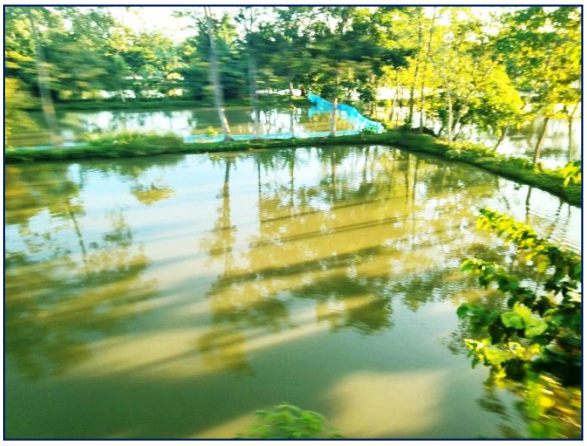
What support he received from APART Project?

The farmer received capacity building training on this subject from the College of Fisheries, Raha. It gave him knowledge and confidence to take up the demonstration. He received critical inputs like advance fingerlings and feed from the project. The technical staff from the college visited his site periodically and extended all kinds of support to the farmer. They also recorded the data and monitored the progress of the demonstration.

How he has done?

Mr. Hasen first earmarked two of his ponds, one of 1 bigh (0.13 ha.) and another of 1.5 bigha (0.2 ha.) for demonstration. In April 2019, he stocked above two ponds with carp yearlings (1000 yearlings in 0.13 ha. pond and 1500 yearlings on 0.2 ha. pond) after proper pond preparation. The stocked yearlings were of 8-9 months old and were the stunted seeds of previous year. The culture continued only for 4 months and from day one, farmer fed fishes daily around 1 PM with the supplementary pellet feed. The farmer at the starting applied 15 kg feed daily which gradually increased up to 40 kg per day. The farmer divided the total feed at 2:3 ratio amongst the two ponds. He

regularly applied lime in the ponds and used zeolite as and when required. He also exchanged water occasionally to maintain water quality. The farmer started harvesting fish from August onwards and continued till September, 2019. Instead of one time harvest, the farmer preferred multiple harvests which helped him to get better price for the produce. The size of the harvested fishes were as follows: Grass carp: 1.5-1.6 kg, Rohu: 700-800 g, Mrigal: 500-600 g, Catla: 1.5-2.0 kg, and bata: 150-200g. The farmer sold them at pond site at the average price of Rs. 120/- per kg for rohu, mrigal and bata; Rs. 140/- per kg for grass carp and Rs. 250/- per kg for mrigal. From two ponds, Mr. Hasen harvested totally about 2900 kg fish with a production rate of about 8800 kg. per ha. The production was beyond his expectation.



Fish Farm of Mr. Abdul Hasen

Farmer sharing information on the demonstration

Expenditure and Return details:

Since the demonstration was of 2 years old, Mr. Hasen could not share details of the expenditure and the return obtained. However, he informed that total expenditure towards the demonstration in 0.33 ha. area was about Rs. 1.8 lakhs against the total income of about Rs. 4.0 lakhs.

Cost Effectiveness:

The demonstrated intervention was very cost effective. The level of profit to the turnover was 55 %, which is quite high.

Outcome:

The demonstration showcased the efficacy of the technology that resulted in high production of carp in short duration by stocking stunted yearlings in pond. The rationale behind this technology is that, the stunted fingerling gained compensatory growth during grow-out phase. The fingerlings whose growth was arrested as juveniles under partial starvation and high stocking

density, was aptly compensated by voracious feeding at low stocking density in grow-out phase. The technology was an eye-opener for the other farmers of the locality. Currently good number of farmers in the area are adopting this method of fish culture.

Challenges faced:

- This farming method relies totally on supplementary feeding. Hence, it involves relatively high operational expenses. Quality of feed also plays a role in production. Despite all these, this method of fish culture is more profitable.
- There is a need to synchronize the seed growing strategy with the short duration fish culture for timely supply of stunted fingerlings at required quantity.

Learning:

- Lack of quality fish feed may be the hurdle in wide adoption of this farming method. Therefore, potentiality of setting up of commercial fish feed mills in Assam should be explored. This will ensure the availability of quality fish feed at reasonable price. In the long run, it will help in boosting the aquaculture sector in the state.

Scope as Adaptation Strategy:

The short duration fish farming offers huge scope as an excellent adaptation strategy for flood-prone areas. Here the fish culture is taken up profitably in post-winter and pre-flood period. The shortening of culture duration will reduce the sensitivity of the fish production to the flooding and will make fish farms less vulnerable to flooding.

Way Forward & Scaling up:

The short duration fish farming was demonstrated in 15 districts of Assam. Barring three cases, all demonstrations showed good results. Since one demonstration was conducted per district, the result should be disseminated far and wide amongst the farmers of the district. As it involves higher operational expense, arrangements may be made to extend short-term credit facilities to the interested farmers. This will help in scaling up the activity. As mentioned earlier, the state should also take necessary steps to set up commercial feed mills through private players.

7 Mapping of Indigenous Technical Knowledge (ITK)

7 ITKs in relation to Climate Resilient Practices in Fisheries

The indigenous peoples and local communities around the world have developed enormous wealth of Indigenous Technical Knowledge (ITK). ITK is the sum total of local or traditional knowledge and practices, accumulated and evolved over a long period of time while dealing with situations and problems in various aspects of life. It includes the skills, beliefs, norms, practices and behaviour patterns handed down from generation to generation. The academics, researchers and communities use different terms for ITK, which includes: indigenous knowledge (IK), local knowledge, folk knowledge, indigenous technical knowledge (ITK), traditional ecological knowledge (TEK), indigenous ecological knowledge (IEK) and indigenous and traditional knowledge (ITK). ITK is essentially the local knowledge that is unique to a given culture or society. Therefore, ITK contrasts with the international knowledge system generated by Universities, Research Institutes and other agencies. Farmers always search for the technology which could be adopted for a longer period of time that suits to their agro-climatic and socio-economic conditions. In this context, ITK is getting importance in search for alternative methods for sustainability. Of late, policy makers, scientific communities and the extension workers have started recognizing the value and importance of ITKs in Fisheries and aquaculture as well.

7.1 ITK in Climate Change Adaptation (CCA)

ITK is one of the dynamic processes in response to the climate variability. The rural population of Assam, especially the tribal communities have rich repertoire of traditional knowledge as they have a prolonged history of survival and coping strategies for the natural calamities like flood, drought, changes in weather patterns etc. for generations. The communities have developed their own ways of adapting to the calamities that have withstood the test of time by evolving in response to changing environment and social conditions. They use ITKs in all stages of disaster management like pre-disaster, during-disaster and post-disaster situations. Apart from that in day-to-day life and in farming practices, we found ample use of ITKs. In a nutshell, ITKs play a significant role in the local level preparedness and coping strategies resulting to lessen the loss of lives and livelihoods. One can see the distinct touch of

the traditional knowledge in their housing type, cultural traits, social relationship, food and seed storage, farming methods, etc.

In the context of capture and culture fisheries in Assam, during survey it is found that ITKs are used in different areas like fish farming, disease management, hatchery operation, fishing, local environmental management practices, etc. There are examples where the local populations have developed and implemented the adaptation strategies through their indigenous knowledge systems, which enable them to reduce their vulnerability to climate variability. There is denying fact that the use of ITK along with modern technologies is paramount for reducing climate vulnerability of the affected people. In the present study, ITKs prevailing in APART project areas were identified, documented and evaluated through group discussion and direct observation. During the discussion, the local knowledge, believes and practices were appreciated and interest was shown in knowing these. Elder and experienced farmers /fishers were given preference to initiate the discussion on various local techniques and practices followed in culture and capture fisheries. The participants held positive attitudes towards the importance of ITK and majority of them agreed to the beneficial use of various ITKs in culture and capture fisheries. The documented ITKs are outlined in the table below.

Table 7.1 ITKs associated with Aquatic Food Production System of Assam

ITK Recorded	Scientific Rationale	Users	Effectiveness					Disclosure platform
			ME	E	LE	IE	CS	
Weather Prediction								
When it rains continuously and heavily in adjacent hills of Arunachal Pradesh and Bhutan, flood water reaches Assam in 6-10 hrs.	Due to continuous and heavy rain in the hills, the rain waters obviously get collected in low lying areas of Assam causing flash flood	Larger communities		✓				FGD
Massive bamboo flowering before summer season is considered as the sign for devastating flood ahead	Traditional knowledge with no known scientific explanation	Local and tribal communities					✓	FGD
If mango trees bear more flowers than that of jack fruit trees in a season, it indicates heavy rain and flood in forthcoming rainy season	Traditional knowledge with no known scientific explanation	Local and tribal communities					✓	FGD
When clouds gather in South-West sky, it indicates about forthcoming storm; if the same is in South-East sky, it indicates heavy rain followed by flood; and if in North-West sky, it indicates normal rain.	Traditional knowledge with no known scientific explanation	Local and tribal communities			✓			FGD
When rainbow extends from North-East to South-West sky and entire rainbow is distinctly visible, it indicates devastating flood ahead	Traditional knowledge with no known scientific explanation	Local communities					✓	FGD
If the ants shift shelter to higher places with their eggs and food stuff, it indicates about impending flood	Some animals are believed to have sixth sense, a special kind of power for sensing the future disasters	Local and tribal communities		✓				FGD

When insects like locust, grasshopper, etc. come out from their hides and fly randomly and enter the houses, it suggest an imminent high intensity weather event like heavy rain with flood	Some insects are believed to have sixth sense that could sense future disasters. Traditional knowledge with no known scientific explanation	Local and tribal communities		✓				FGD
When foxes howl impatiently from higher place, it indicates the forthcoming prolong dry season and when foxes howl from low lying place, it indicates the forthcoming flood.	Some animals are believed to have sixth sense, a special kind of power for sensing the future disasters	Local and tribal communities					✓	FGD
Placing of coconut and palm leaves in the pond as shelter for fishes to overcome hot summer.	Long and broad leaves of coconut /date palm are tied to with bamboo poles and are fixed at the pond bottom. It prevents penetration of sunshine into the water and provides shade. This act as shelter for fishes and helps in overcoming the hot summer.	Large and medium farmers	✓					FGD
Water Quality								
Use of cow urine to control algal bloom in fishpond	Cow urine has a potential prophylactic agent which acts against the algal bloom and helps in controlling the algal bloom in fishpond.	Small and marginal farmers		✓				FGD
Use of freshly burnt ash of cow dung / paddy straw in ponds to maintain water quality and check disease outbreak.	Ash helps in settling of suspended organic matters and thereby improving the water quality. Ash contains Ca which helps in increasing pH of pond water and may have some anti-microbial property.	Small, medium and marginal farmers	✓					FGD
Use of branches of drumstick (*Moringa oleifera*) and Tamarind (*Tamarindus indica*) trees to reduce water pH	Stems and branches of drumstick and Tamarind trees are believed to help in bringing down the pH of pond water. Thus, beneficial if pond water is alkaline.	Small and marginal farmers					✓	FGD
Disease control								

Use of chopped pseudostem of banana plant in ponds to maintain water quality and check disease outbreak.	Juice in banana pseudostem may help in increasing the pH of pond water, improve the water alkalinity and overall water quality. The semi-decomposed stem is eaten by some fish like grass carp	Small, medium and marginal farmers	✓					FGD
Application of turmeric powder and neem oil mixture on the ulcers of affected fish	Neem and turmeric are known to have antimicrobial properties. The application of the mixture of two may be effective in healing ulcer. Curcumin and azadirachtin are the active ingredient s in turmeric and neem having therapeutic effects.	Small, medium and marginal farmers	✓					FGD
Use of old gunny bags submerged in fishpond to control argulus (fish lice) in fishpond	Farmers keep old gunny bag submerged in pond water and remove them periodically to dry and kill eggs of argulus deposited over them.	Large and Medium farmers		✓				FGD
Use of mahua (*Madhuca longifolia*) oil cake at very low dose to make fish hardy	Mahua oil cake is packed in gunny bags @ 10-15 kg and immersed at two corners of a pond. It is believed to make the fishes hardy and resistant to disease, and thus reduce the mortality rate.	Large and Medium farmers		✓				FGD
Use of bamboo poles and branches in the pond to control argulus (fish lice) and also to prevent poaching	Bamboo poles are fixed in the pond at different places and the bamboo branches. It helps in controlling fish lice by providing rough surface for rubbing of the fish body and getting rid of fish lice. It also helps in minimising the poaching.	Small, medium and marginal farmer		✓				FGD
Fish as diet & therapeutic use in human								
Eating fish curry of live fish like *Channa gachua* (chang) and *Heteropneustes fossilis* (Sighi fish) to boost up energy of the patient	It is a part of folk medicine system. Believed to have extra nutritional benefit as compared to other fishes. These species are readily available in live condition so that patients can eat fresh ones.	Widely and commonly used across the state		✓				FGD

Eating the soup of *Clarias batrachus / Heteropneustes fossilis/ Monopterus cuchia* to fight against anaemia	It is a part of folk medicine system. The soup mixed with powdered red chilli and black pepper is drunk once for 3-4 days. Believed to increase the RBC in blood.	Commonly used across the state		✓				FGD
Fishing Methods								
Katal / Jeng Fishing in *Beels* of Assam (explained in detail in the box below)	Traditional method of capturing fish by constructing fish aggregating structure with locally available materials.	Widely and commonly used across the *state*	✓					FGD
Use of bamboo made fishing traps of different shapes and designs to catch fish from rivers and wetlands	The traps are so designed that once the fish is entered it cannot escape. It varies in shape and design based on the ethnicity and places. However, all are low cost, effective and eco-friendly.	Local Fishers	✓					FGD
Use of raw duck meat as attractant to catch small cat fish (*Mystus sp.*) from rivers and rivulets	Strong flavour of duck meat attracts small cat fishes to shallow pit dug on the marginal area of the river with mild water current and placed inside the squeezed duck meat. Commonly practised during non-rainy season (October-April)	Local Fishers		✓				FGD
Use of various Plant materials containing fish toxin to catch fish	The extracts of some specific plants are extensively used as fish catching agents mostly in dry months from natural water bodies.	Local and tribal communities	✓					FGD
Use of crushed leaves of water pepper (*Polygonum hydropiper)- Pani-morich* in Assamese to catch the air breathing fishes like *Channa spp.*	The crushed leaves are inserted in the holes of the fish, which irritate them and make them compel to come out from the hole.	Local and tribal communities		✓				FGD
Use of crushed root of *Derris elliptica (a* perennial climbing shrub) – *Kaliya Lata* in Assamese to catch mud *eel* (*Monopterus cuchia*)	The roots of *Derris elliptica* contain rotenone, a strong fish poison. The crushed material is inserted in the hole of eel in such a way that there is enough space for the eel to come out. The fisher patiently waits near the hole with a wounding gear. Unable to withstand the irritation caused by the	Local and tribal communities	✓					FGD

	toxin, the fish come out of the hole and is caught by fisher.							
Use of crushed root of *Millettia pachycarpa* (a perennial climbing shrub, commonly called as fish poison climber) to catch fish from stream	The juice extract of crushed root of the plant is widely used as fish poison in traditional fishing. Fish get paralyzed and then collected by hands or nets.	Local and tribal communities	✓					FGD
Fish Processing								
Use of fermented ethnic fish products like *Shidal* in the diet of tribal people in Assam	Shidal is a salt-free fermented product prepared from *Puntius sp.* (generally *Puntius sophore*) and popular due to its strong flavour.	Local and tribal communities	✓					FGD
ME: Most Effective, **E:** Effective, **LE:** Less Effective, **IE:** Ineffective, **CS:** Can't say								

Box 7.1 Description of *Katal / Jeng* Fishing

Katal/Jeng Fishing

Katal / Jeng Fishing is a method of capturing fish by constructing traditional fish aggregating structure which is extensively used in the *beel* fisheries of Assam. The method was probably brought to Assam region by the fishermen who migrated from Bangladesh and now widely used as a profitable method of fishing in *beels*. It is commonly known as "*Katal*" and in lower Assam called as "Jeng". An area of the *beel* is marked and encircled with the help of bamboo poles. Branches of the tree / bamboo are placed within the encircled area and floating water hyacinth (*Eichhornia crassipes*) is spread over them. The branches of bush forming tree, locally called as *Sheora* (*Strebulus asper*) is used. It is believed that the bark of this tree attracts the fish to the enclosure and fish eat them. Bamboo strips are used to encircle the whole area to prevent escape of water hyacinth. The circumference of the *Katal* generally varies from 200 to 350 meters. The area of about 4-6 meters around the outer periphery of *Katal* is denoted as "No fishing area", where no boats are allowed to operate. The method is very simple and with low investment, but requires a long time between installation and harvesting. The installation period of *Katal* is soon after monsoon (September-October) when the *beel* water starts receding. In suitable places with water depth varying from 1.5 - 3.0 m, the *Katals* are arranged and lie dispersed all over the *beel*. These are then left as such up to 2 - 3 months. *Katal* lures the fishes to accumulate within the bushes, weeds and tree branches for a period of 2-3 months, where they form their abode and are finally caught by enclosing the area. When the *beel* water recedes, fishing starts. A few days, prior to the harvest, the *Katals* are encircled by net locally called as "*Katal mara jal*". When the actual fishing starts, a group of 20-30 fishermen depending upon the size of *Katal* enter the encirclement. The vegetations and branches are removed and the circumference of *Katal* is gradually reduced by dragging the net inwards. Then with the help of cast nets, encircling gears, *Thella jal*, etc. the fishes are caught. The operation is carried out by boat and nets. It lasts for about 8 - 12 hours and complete harvesting of the *Katal* is done at a stretch. In certain *beels*, after complete harvesting, again the *Katal* is arranged with the help of same bushes, tree stoops and bamboos, which are then harvested after 1-2 months.

7.2 Establishment of Intellectual Property Rights (IPR) for ITKs

The need for protection of ITKs emerged after several incidences such as United States Patent & Trademark Office (USPTO) grant on wound healing property of turmeric and basmati rice in the late 1990s, and patents grant on *neem*-based bio-pesticide by the European Patent Office (EPO). Immediately after these episodes, India came up with scouting of ITKs and documenting them in Traditional Knowledge Digital Library (TKDL). TKDL is a collaborative project between the Council of Scientific and Industrial Research (CSIR), the Ministry of Science and Technology, and the Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homeopathy (AYUSH), Ministry of Health and Family Welfare, Govt. of India. Internationally several laws and conventions such as Convention on Biological Diversity-CBD (1992) and Nagoya Protocol (2010) ensures benefit sharing, but they do not recognize rights over already published traditional knowledge in public domain. Also, the community need to depend on the users for drawing benefits. On the other hand, intellectual property right (IPR) can be used to protect and draw benefit to the communities.

The Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement under WTO encompasses seven areas of intellectual property right (IPR), viz. (i) copyright, (ii) trademarks, (iii) trade secrets, (iv) industrial designs, (v) geographical indications (GI), (vi) patent and protection of plant varieties, (vii) layout designs. Among these IPRs, patents and GI could help communities to protect and promote some of their ITKs. Though patents are stronger IPR, it is less used for ITK as the challenge exists in establishing novelty and inventive step. Therefore, GIs could be used as a legal toll for protecting ITKs. There are some documented cases of ITKs from agriculture sector of India, being protected using GIs. Darjeeling Tea, Basamati Rice, Pokkali Rice, Navara Rice, Feni are few examples of ITKs which have received protection under GI. The *Pokkali* is a traditional rice-fish integration system unique to a geographical location of Kerala. In the box below, the case of ITK on *Pokkali* which was granted IPR in form GI is illustrated.

Box 7.2 Description on GI tag for *Pokkali* Rice

Pokkali Rice

Pokkali is a unique saline tolerant rice variety that is cultivated using extensive aquaculture in an organic way in the water-logged coastal regions, spread in about 5000 hectares area in Alappuzha, Thrissur and Ernakulam districts of Kerala. It constitutes three major unique components; land, varieties and system of cultivation. A unique wet land streaking from Vembanad Lake to Arabian Sea is being used. The rice is cultivated from June to early November when the salinity level of the water in the fields is low. From mid-November to mid-April, when the salinity is high, fish and prawn

farming take over. The fish and prawn seeds swim in from the sea and the backwaters after the rice harvest and feed on the leftovers of the harvested crop. Sluice gates are used to control the water flow to the fields. *Pokkali* is a natural system of cultivation with no plant protection chemicals and fertilizers application. The rice crop draws nutrients from the excrement of fish and prawn, and other remnants. These unique characteristics qualified it for GI tag. Several efforts were undertaken by the farmers and other government and non-government agencies in this regard and application was submitted in Geographical Indications journal in May 2008 and granted GI certificate on December 2008.

Like Kerala, Assam has also long tradition of paddy-fish integration in low laying areas. In order to derive additional value from this climate resilient practice, the possibility of obtaining IPR in the form of GI tag for this practice may be explored with the help of WorldFish and IRRI. If accomplished, both rice variety and fish produced from the system will fetch premium price and will provide economic benefit to the farmers /region/state, apart from conferring legal protection.

The protection of ITK from the angle of the IPR refers to its protection against some form of unauthorized or inappropriate use by third parties. The objective of protection is to make sure that ITK is not used without authorization, or misused. Documenting ITKs is often discussed as a way of guaranteeing the social, cultural and economic interests of indigenous peoples and local communities. It is emerging as a tool that can hold back further loss of ITK, maintain ITK over time, support benefit sharing between holders of ITK and those who use it, and ultimately protect ITK from unwanted uses. But just documenting ITK is not in itself an effective strategy for protecting it. Documentation does not necessarily ensure legal protection for ITK. There are concerns that documenting ITK may mean that communities lose control over it, make it widely available, compromise the secret nature of some ITK, and so on. Therefore, irrespective of the potential pros and cons of documentation of ITK, IPR is an important issue in the documentation process. Two forms of IPR may be encountered, positive and defensive protection. Positive protection grants ITK holders intellectual property rights and empowers them to use those rights for their own purposes. Defensive protection allows ITK holders to prevent or stop people not belonging to the community from illegally acquiring intellectual property rights over their ITK.

The documentation of ITK for IPR involves a planned, conscious and informed process of knowledge gathering and may serve many purposes, including:

- establishing positive rights in relation to ITK
- preventing the erroneous granting of IPR over ITK-related innovations (defensive protection)
- making ITK available to a wider audience (researchers, students, entrepreneurs, etc.)

- creating new IPRs through the scientific validation of ITK and collaborative research and development
- preserving, safeguarding or promoting ITK and transmitting it to future generations
- helping in designing and implementing benefit-sharing schemes

Table 7.2 Intellectual Property (IP) Assessment Framework for ITK (modified from Documenting Traditional Knowledge - A Toolkit, WIPO, 2017)

Attributes	Descriptions	Assessment Details
Objectives	Objectives of documentation of the ITK	▪ Establishing positive rights for ITK? ▪ Preventing the erroneous granting of IPR over ITK-related innovations? ▪ Making ITK available in a systematized manner to a wider audience? ▪ Creating new IPRs through scientific validation of ITK? ▪ Preserving, safeguarding or promoting ITK and transmitting it to future generations? ▪ Designing and implementing benefit-sharing schemes? ▪ Using ITK for specific community-oriented objectives? ▪ Other objectives?
Subject matter	Nature of the ITK	Is the ITK: - ▪ Secret and confidential? ▪ Sacred? ▪ Individually or communally held? ▪ Orally transmitted? ▪ Documented and systematised in some form? ▪ Already partially documented? ▪ Subject to customary restrictions for use or disclosure? ▪ Any other important characteristics?
	Content or expression of the ITK	Is the ITK: - ▪ Technical knowledge or know-how? ▪ Embodied in a tangible product? ▪ Related to traditional cultural expressions? ▪ Are there any other significant issues regarding its content or form of expression?
	ITK and biological/ genetic resources	▪ Would specific biological or genetic resources be collected? ▪ Would preparations, mixtures or extracts be collected and documented? ▪ Are the biological or genetic resources instilled with distinctive characteristics developed through traditional methods of selection, breeding or processing? ▪ Are the biological resources endemic?

		▪ Any other issues regarding biological/ genetic resources?
	How widely is the ITK used or disseminated?	▪ Known by a community individual or leader or elder, the community as a whole, a group, or other social actors? ▪ Disclosed to: -the general public (publicly or widely available)? -individuals who do not belong to the community (such as researchers or students)? ▪ Is ITK commercialized or traded in some form? Locally, regionally or internationally? ▪ Any other issues in relation to use and dissemination?
Actors	Role and rights of the different stakeholders	▪ Who leads the process? ▪ Which role will each actor play? ▪ Who will write down, film, record, translate and compile ITK? ▪ To whom will the IPRs that arise belong? ▪ What rights will indigenous peoples and local communities retain? ▪ Any other issues in relation to different stakeholders?
Potential clients or users	Who is intended to get benefit?	▪ Indigenous peoples and local communities? ▪ Intellectual property offices? ▪ Researchers? ▪ Other people or organizations?
Applicable intellectual property legislation	Applicable national and international legislation	▪ What specific laws and regulations are applicable to the subject matter? Are there specific laws on ITK? ▪ Who can provide specific intellectual property advice in this regard? WIPO, IP experts, local NGOs, the documentation proponents? ▪ Any other issues relating to the applicable law?
Other related legal regimes	Other relevant legal regimes and instruments	▪ Customary laws and local traditions? ▪ Community protocols? ▪ Biodiversity laws and access and benefit-sharing legislation? ▪ Any other relevant laws or rules?

8 Addressing Gaps in Adoption of Technology

8 Gap Analysis in Climate Resilient Practices and Technology Adoption

Large scale adoption of technological innovations and resilient practices are essential for the sustainable development of aquatic food production system in Assam. Since the climate resilient practices and the technologies in aquatic food production system are relatively new to the stakeholders including farmers and fishers, the wider adoption of these technologies is difficult unless the constraints and bottlenecks are addressed properly. Though Assam has professional extension officers at district and block levels to help farmers in adoption of new technologies, still a wide gap exists between technologies and their successful adoption in farmers' field. Hence, gap analysis will help to examine and assess the current performance of these technologies against the potential or intended performance. Unavailability of critical inputs in time, lack of customization of technology to local needs, economic barriers, social issues, lack of coordination between different government agencies or different levels of government, complexity of interdisciplinary approach, etc. are some of the commonly encountered problems. Often the information provided by the extension personnel appears to lack relevance to the need of the farmers. An attempt is made to analyse the gaps in adoption in resilient technologies being implemented under APART.

Table8.1 Gap Analysis Framework for Climate Resilient Practices and Technologies promoted under APART

Name of the Technology	Current Performance	Intended Target	Gap Analysis		
			Gaps / problems Identified	Nature of Problem	Steps proposed to reduce the Gaps
Short duration Fish Farming	Demonstrations conducted by College of Fisheries, AAU under APART in 15 districts in 2019-20. Success rate was high during demonstration. The production rate was 6.0-6.4 t /ha. /Crop	Upscaling the activity horizontally and making it as a main stream activity, especially in flood prone areas. Making the activity more profitable and less affected by climate-induced risks.	Limited availability of stocking material (advanced fingerlings) in time	Moderate Problem	▪ Brining more areas under seed growing activities ▪ Synchronising the seed growing strategy for timely supply of stocking material ▪ Quality seed production & early breeding in hatcheries
			Limited availability of formulated feed	Moderate Problem	▪ Establishment of more feed mills in the state
			Moderate sale value realization	Moderate Problem	▪ Creating facilities for transportation and marketing of hotel-size fish in live condition for high sale value realization
			Dissemination gap	Minor Problem	▪ Dissemination of technology through training and demonstration. Extending hand-holding support for scientific adoption.
Overwintering of Seed (Production of Stunted Yearling)	Demonstrations conducted by College of Fisheries, AAU under APART in 13 districts in 2019-20. Success rate was high in demonstration. The production rate was 2.8-4.4 t /ha. /Crop. It is gaining popularity as a strategy to	Upscaling the activity in new areas. Use overwintered seed as stocking material produces big size fish that fetches premium price in the market. Replacing the conventional carp polyculture with this technology	Lack of awareness and knowledge about the technology	Moderate Problem	▪ Dissemination of technology through training and demonstration. Extending hand-holding support for wider adoption.
			Inadequate rearing areas for production of stunted seed	Major Problem	▪ More rearing areas for production of stunted seed may be developed in the vicinity of potential areas. ▪ Farmers to be incentivised to setup seed rearing farms, especially in deficient areas to ensure year-round availability of quality stocking material. ▪ Launching of Govt. scheme on this activity.

	grow big size fish in short time.				
Paddy-Fish Integrated Farming	Scientific demonstrations were conducted by ARIAS Society under APART in last 3 years (42 ha in 18-19; 100 ha in 19-20 & 289 ha in 20-21) with high success rate. Fish production varied from 0.5 to 1.5 t/ha.	Bringing more areas under paddy-fish integrated farming, especially in low-lying regions. Slowly transforming entire activity into organic production system and exploring the possibility of GI tag for the system, like *Pokkali* in Kerala. Increasing fish species diversity.	Use of chemicals/pesticides in paddy.	Moderate Problem	▪ Chemicals/pesticides banned by Government should be removed from Better Management Practices (BMP).
			Needs to widen the fish species diversity in paddy-fish system	Minor Problem	▪ Inclusion of SIS and air-breathing species along with carps for better yields and income.
			Use of paddy fields in raising carp seed	Minor Problem	▪ Developing the protocol and SoP for use of paddy fields in raising carp seed. Same can be used as stocking material for pond culture
			The paddy-fish concept should become part of the agricultural system rather than the fisheries system	Major Problem	▪ Change in approach. For dissemination of the technology, the Agriculture Department and IRRI should take the central role while the Fisheries Department and WorldFish should be in supporting role.
Polyculture of carps in pond	Promoted by ARIAS Society under APART as a scientific way to make fish farming more profitable with higher production level. Success rate is high. Fish production varied from 5.0 to 6.0 t/ha depending on management and level of use of inputs.	To make it as an obvious way of fish farming throughout the state. To bring the under-utilized and un-utilized water bodies under scientific carp polyculture.	Lack of quality fish seed	Major Problem	▪ Introduction of quality seed production programme with schemes for Hatchery Accreditation and Fish Seed Certification.
			Lack of low-cost fish feed	Major Problem	▪ Establishment of more feed mills in the state and use of local ingredients for feed production.
			Lack of laboratory for water quality testing and fish disease diagnosis	Moderate Problem	▪ To set up laboratories for water quality testing, fish disease diagnosis and testing the quality of critical inputs
			Lack of aquaculture support service	Moderate Problem	▪ Promoting start-ups in ICT-enabled Aquaculture support service across the state

Multiple stocking and multiple harvesting of carps	Promoted by ARIAS Society under APART as polyculture of carps with modified frequencies in stocking and harvesting. A culture is continued for 3 years in the same pond. Fish production rate is 6.0 to 6.5 t/ha/ yr. (av. of 3 yrs.)	Bringing more areas under this practise in the regions where it is beneficial. Need to maintain a fine balance between total fish biomass and carrying capacity of the pond.	Ensuring year-round availability of seed of desired size and quantity	Moderate Problem	▪ Farmers to be incentivised to setup seed rearing farms, especially in deficient areas to ensure year-round availability of quality stocking material.
			Limited availability of formulated feed	Moderate Problem	▪ Establishment of more feed mills in the state
			Lack of knowledge on the technology	Minor Problem	▪ Developing the protocol and SoP. Emphasis should be on use of net with appropriate mesh size so that fishes less than 250g can easily escape and netting at regular intervals to facilitate release of noxious gases from bottom and mixing of bottom nutrients with surface water.
Polyculture of Carps along with *Mola* and other Small Indigenous Species (SIS)	Promoted by ARIAS Society under APART as a nutrition-smart approach to increase pond production and profitability. *Mola* is performing very well in carp polyculture system. Being a self-recruiting species, it matures and breeds in the pond.	Wider adoption of the technology in pond aquaculture (both small and large ponds) across the state.	Limited supply of stocking material	Major Problem	▪ Standardisation of protocol and SoP for captive natural breeding in the pond. ▪ Development of commercially viable induced breeding and nursery technology for *mola*.
			Lack of knowledge on the technology	Moderate Problem	▪ Hands-on training to farmers on production, harvesting and supply of brood stock of *mola* to new farmers.
			Lack of value addition	Major Problem	▪ Standardisation and commercialization of value-added products like dry fish, fish pickle, etc. from *mola* and other SIS
			Limited market demand	Major Problem	▪ Popularizing SIS among vulnerable groups of pregnant and lactating women, infants, children, etc. ▪ Incorporating SIS as nutritional supplement in Government-aided schemes including Integrated Child Development Services (ICDS) and Mid-day school meals.

Polyculture of Carps and Freshwater Prawn (*Macrobrachium rosenbergii*)	Promoted by ARIAS Society under APART as a strategy to include high-value species in carp polyculture to increase pond income and profitability. Farmers are getting premium price for the prawn & very happy with production.	To carve out a niche for freshwater prawn in the aquaculture landscape of the state.	Lack of seed	Major Problem	▪ To tie-up with the hatcheries of other states like West Bengal, Odisha, Andhra Pradesh etc. in advance for steady supply of prawn seed to Assam. ▪ To explore the possibility of setting up of prawn hatchery in Assam as a long-term strategy.
			Lack of prawn feed	Moderate Problem	▪ To make prawn feed available locally for the farmers
			Lack of knowledge on the technology	Moderate Problem	▪ To extend training and hand holding support to the farmers.
Cage culture in *Beels* for raising fingerling and table fish	Demonstrations conducted by College of Fisheries, AAU under APART in selected *beels* in 2020-21.	Wider adoption of the technology in the *beels* of Assam for raising fry to fingerling as stocking material for *beels* and also for production of table fish.	Financial constraint as it involves capital investment	Moderate Problem	▪ Installation of cage at subsidized should be the priority. ▪ Use of low-cost local materials like bamboo should be encouraged in cage fabrication
			Lack of social and motivational support	Moderate Problem	▪ Active involvement of *beel*-dependent communities in the management of cage
			Lack of knowledge on the technology	Moderate Problem	▪ To extend training and hand holding support to the fishers of the *beel* on cage culture
Production improvement in *Beel* through fish stock enhancement	Promoted by ARIAS Society under APART in selected *beels* in 2020-21 as a measure to enhance fish stock through selective stocking of commercially	Wider adoption of the technology in the *beels* of Assam in increasing the fish production by utilizing the unused trophic and spatial niches of the *beel* ecosystem efficiently.	Limited availability of stocking material of local origin	Moderate Problem	▪ Avoiding the stocking of exotic species and carnivore species.
			Lack of knowledge on the technology	Moderate Problem	▪ To use the stocking materials from local hatcheries. Because, the Brahmaputra River system harbours pure gene pool of native fish germplasm including Indian major carps. The open *beels* are connected with parent river. Therefore, stocking of seed of the native

	important fast-growing fish species.				species with different strain may pollute the purity of native germplasm of fish in the river. This will have long-term negative consequences.

9 Integrating Value Chain with Climate Resilience

9 Integrating Fish Value Chain and Climate Resilience

9.1 Fish Value Chain

Fish value chain can be defined as a chain of sequential activities starting from the fish production system till it reaches the consumer and at each activity the product gains some value. It has core activities, which include the basic activities related to production, and the external activities grouped as upstream and downstream activities. Upstream activities provide inputs into the core activities, while downstream activities relate to the outputs from the core activities. In the context of Assam, the participants involved in entire value chain in aquaculture can be categorized into six categories, i.e. (1) Input suppliers, (2) Service providers, (3) Producers, (4) Marketing intermediaries, (5) Processors and (6) Consumers. A diagrammatic flow chart depicting value chain of culture fisheries in Assam is given below.

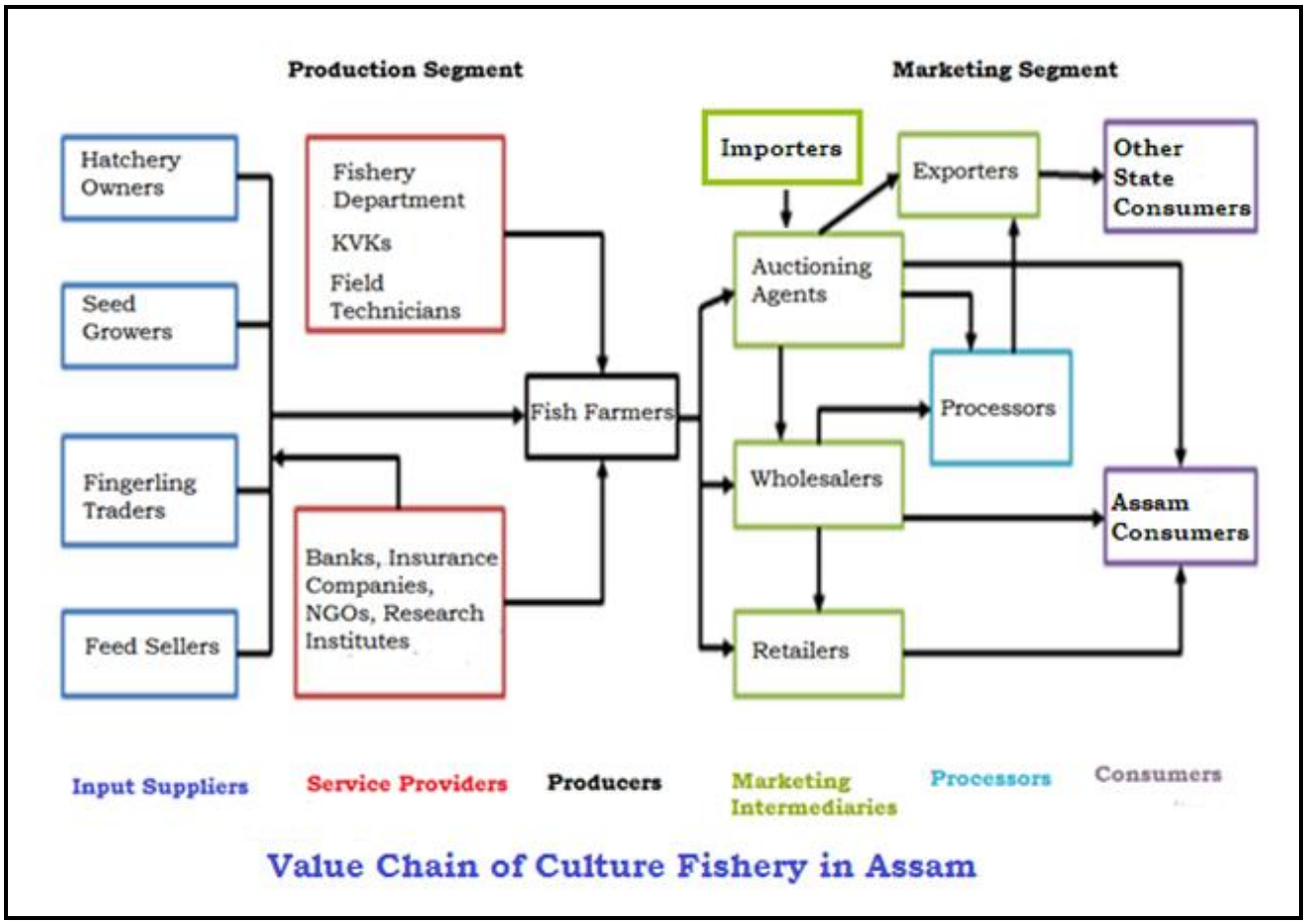


Figure 9.1 Illustrative Value Chain Participants in Culture Fishery of Assam

To develop the sustainable aquatic food production system, it is necessary that entire fish value chain is made climate-proof through climate resilient technologies and policies. To achieve this, the interventions need to be selected on the basis of their vulnerability to climate change; their potential

contribution to climate change adaptation and mitigation; and their ability to improve the resilience of producers and other value chain actors (FAO, 2019). With climate change threatening fishery value chains at all stages, from production to processing and marketing, understanding the associated climate risks at each stage and having the value chain approach to climate resilience is key to risk management. A conceptual framework for step-by-step mapping of Fish Value Chain from climate resilience viewpoint is illustrated here.

Table 9.1 Conceptual Framework for Mapping Fish Value Chain (modified from Sanogo, 2010)

Steps	Elements	Methodology	Description
Step **1**	Mapping the core processes in the fish value chain	Desk study	It is the first step that distinguishes the key processes of the fish value chain. Ideally it should consist of six to seven major steps, starting from production to the end consumer.
Step **2**	Identifying and mapping the main actors involved in these processes	Desk study	This step deals with identifying the main actors like producer, input suppliers, processor, wholesalers, retailers, consumers, etc. and mapping their roles. Depending on the level of detailing desired in the mapping exercise, the actors can be further categorized into different sub-categories.
Step **3**	Mapping climate change risks and vulnerability	Field visit	This facilitates the in-depth analysis of adaptive capacities at each stage. It is important to apply intersectional analysis. This is necessary to understand the linkage between value chain actors and climate vulnerability.
Step **4**	Mapping the number of actors	Field visit	It involves interviews with key stakeholders combined with secondary research. It will require a statistically significant sample size of actors at each node.
Step **5**	Financial analysis	Field visit	The financial analysis of a fish value chain entails the study of both historic and current costs and margins. The former allows the user to determine if the value chain (or a particular process) has the potential to grow in future, while the latter enables the user to find out if the value chain (or a particular process) is accessible to a particular participant, and whether it is a good source of income for them.
Step **6**	Mapping the flow and volume of products	Field visit	The flow of tangible goods in a value chain (such as products, services or cash) will be mapped at each step, from production to end consumer
Step **7**	Mapping the flow of information and knowledge	Field visit	Mapping the flow of intangibles (such as information or knowledge) can assist the user in determining whether a specific target group is participating in the exchange of information and knowledge. Mapping the flow of intangibles is more complicated than mapping the flow of tangibles.
Step **8**	Mapping relationships and linkage between value chain actors	Field visit	In a value chain, relationships can be inter-actors and/or intra-actors. The nature of these relationships can be crucial in determining factors, such as bargaining power, and therefore assist the user in ascertaining the benefit and income for each actor.

Step **9**	Mapping the enabling environment of the value chain	Field visit	The rules and regulations that govern a value chain (or parts of it) and the business services that feed into the value chain may provide crucial information regarding the value chain itself, thereby giving the user an overview of the potential to intervene outside the value chain
Step **10**	Market analysis	Field visit	It is the study of the market through different lenses, such as market size, market growth rate, market trends, profitability, etc. Conducting a market analysis would enable the user to identify the constraints and opportunities pertaining to expanding the market for the selected value chain.
Step **11**	Mapping the gender responsiveness of the value chain	Field visit	For gender-responsive value chain mapping, at each level of analysis gender-responsive indicators are used and gender-disaggregated information is collected

Table 9.2 Value Chain Mapping of Carp polyculture in Assam with adaptation options and suggested actions

Value Chain Actors	Key Functions	Adaptation Options	Suggested Actions	Agencies to be involved
Hatchery Owners	Brood Collection and Management; Breeding and Hatching	▪ Germplasm Improvement ▪ Hatchery Registration and Accreditation Plan ▪ Seed certification scheme	▪ Screen the species/ strain for heat and disease resistance ▪ Breeding of indigenous aquaculture candidate species ▪ Adoption of BMP in fish breeding and hatching, ▪ Discouraging inbreeding practices ▪ Climate Adaptive Breeding Programme like early maturation and early breeding ▪ Skill training and refresher courses for hatchery operators and technicians	DoF, NFDB, CoF, CIFA, NBFGR, WorldFish,
Seed Growers	Raising spawn to fry and fingerling	▪ Adherence to good seed rearing practices ▪ Encouraging the production of fingerling, advance fingerling and stunted yearling ▪ Promoting overwintering of seed	▪ Developing SOP for climate resilient seed production ▪ Developing clusters on seed rearing facilities in potential areas ▪ Building the network of hatchery owners, seed growers and farmers for traceability and maintaining the quality ▪ Training & demonstration programmes on climate resilient seed production	DoF, NFDB, CoF, CIFA
Seed Traders	Buying seeds from Hatcheries/nurseries and selling to the farmers	▪ Introduction of customized vehicle for seed transportation ▪ Adherence to climate adaptive seed transport methods for better survival	▪ Developing SOPs on acclimatization, grading, counting, packing and transportation of seed ▪ Discouraging inappropriate transportation practices ▪ Demonstrating the benefit of scientific transportation methods	DoF, NFDB, CoF, CIFA

Grow-out Farmers	Production of table size fish	▪ Develop a system for timely issuing of short-term weather forecasts ▪ Strengthening the early warning systems ▪ Improvement of disaster risk preparedness and management ▪ Mainstreaming the climate resilient practices especially in areas vulnerable to hazards like flood, drought, etc. ▪ Surveillance programme for early detection of new diseases in fish	▪ Promoting sustainable farming practices for increasing the climate resilience ▪ Adjusting the calendar of farming operations with seasonal weather forecasts and changing climate scenario ▪ Adoption of climate-smart practices like short duration fish farming, Deep-water Rice-fish integration, livestock-fish integration, effective dyke management and intercropping in dyke, Stocking of self-recruiting species, etc.	DoF, NFDB, CoF, CIFA, NBFGR, WorldFish
Input Suppliers	Supplying feed, aqua-chemicals and medicines	▪ Wide promotion of feed-based aquaculture ▪ Strict quality control and compliance measures for inputs ▪ Preparation of post-flood contingency plan with inputs	▪ Establishment of feed plants in the state & emphasis on use of local ingredients ▪ Framing regulations for quality control of feed and other inputs ▪ Establishment of Input testing laboratories ▪ Prohibition in use of banned antibiotics and chemicals.	DoF
Arotdar (Commission-ing Agents)	Facilitate bidding between farmers and wholesalers; give money on credit to farmers	▪ Developing climate proofing infrastructure for post-harvest operations ▪ Regulations for quality control across the value chain against all kinds of adulteration practices	▪ Modernization of auctioning centres with icing and storage facilities ▪ Create more awareness amongst the trading intermediaries about the need for quality control and compliance	DoF, NFDB, CoF, CIFT
Wholesalers	Trading, buy from *Arots* through auction and sell in bulk to the retailers	▪ All-round infrastructural development in fish marketing ▪ Maintaining the cold chain during transportation and storage	▪ Creation of Modern Hygienic Wholesale Fish Markets ▪ Training wholesalers on good practices in fish handling and preservation	DoF, NFDB, CoF, CIFT, NIFPHATT

		▪ Reduction in post-harvest losses	▪ Insulated and refrigerated transport vehicles for fish	
Retailers	Retailing, sell to the consumers	▪ Maintaining the quality of fish during retailing ▪ Promoting the sale of live fish for high value realization	▪ Creation of infrastructures like modern Hygienic retail fish Markets, retail outlets, fish display units, mobile fish vending units, live fish selling units, etc. ▪ Training retailers on good practices in fish handling and dressing	DoF, NFDB, CoF, CIFT, NIFPHATT
Service Providers	Providing various fishery related ancillary services	▪ Risk Mitigation Service ▪ Extension Service ▪ Credit Delivery System	▪ Fish crop insurance ▪ Need-based and problem-solving extension service ▪ Value-based credit facilities at the door-step of small farmers	DoF, NFDB, AAU, CoF, KVKs, NABARD, MFIs
R & D Institutes	Conduct research studies on Climate Change & its impact on Fisheries	▪ Research studies on heat and drought resistance physiology of fish ▪ Developing resistant fish strains / varieties	▪ Developing Research Institutions' capacity for conducting research on climate resilience in Fisheries ▪ Creating facilities necessary to undertake controlled environment research in Fisheries	AAU, CoF, CIFRI-Guwahati Centre, CIFA
Processors	Value addition through processing and preservation	▪ Emphasizing some ethnic fermented fish products of the region for	▪ Refinement of traditional processing technologies with scientific intervention	CoF, DoF, CIFT
Consumers	End user of fish and fishery products	▪ Highlighting the nutritional and health benefits of fish as food ▪ Awareness on hygienic handling and cooking of fish and fishery products	▪ Creating consumers' awareness on food safety and adulteration practices ▪ Sensitizing consumers on ecosystem approach to aquaculture and about ecolabel concept in Aqua products ▪ Popularizing value-added fishery products amongst consumers	DoF, NFDB, CoF, CIFT, NIFPHATT

Table 9.3 Domain-wise mapping of climate resilient strategies for *Beels* of Assam (modified from Chandra, 2009)

Domains of Management	Components	Outcomes	Climate resilient Strategies	Agencies to be involved
Natural Process	▪ Nutrient assemblage ▪ Auto stocking ▪ Connectivity to River ▪ Biodiversity ▪ Flooding	▪ Techno-managerial options ▪ Production possibilities ▪ In-situ conservation ▪ Sustaining ecosystem	▪ De-siltation of *Beels* ▪ Opening and widening of linkage channels ▪ Sustainable strategies for productivity	AFDC, DoF, Water Resources Dept.- GoA, CIFRI, CoF
Human Intervention	▪ Overall *Beel* Management ▪ Fishing practices ▪ Efforts ▪ Weed control ▪ Bunds and spillways ▪ *Katal or Jeng*	▪ Sustainable production ▪ Productivity enhancement ▪ Resource use	▪ Adoption of Fisheries improvement Programme ▪ Promoting climate resilient native fish species ▪ Improvisation of fishing gears & tools ▪ Judicious exploitation of Resources ▪ Creating appropriate number of deep pools	AFDC, ARIAS Society, WorldFish
Intervening Agencies	▪ Individuals & Groups ▪ Community ▪ Govt. Departments ▪ Scientific organization ▪ Financial institutions	▪ Efficient resource use ▪ Increased participation ▪ Livelihood security ▪ Fishing ban & holidays ▪ Technology adoption ▪ Resource monitoring	▪ Sensitizing stakeholders on Climate change issues ▪ Early warning system ▪ Prevention of anthropogenic stress on *Beels*	AFDC, NFDB, ARIAS Society, WorldFish
Institutional Linkage	▪ Institution Building ▪ Social Interaction & process ▪ Property relationship	▪ Rules and Norms ▪ Conflict resolution ▪ Increased participation ▪ Access to resources	▪ Ecosystem/integrated approach for wetland management ▪ Diversified livelihood options for aboriginal fishermen	ARIAS Society, WorldFish, AFDC, NFDB

	▪ Social Institutions ▪ Market agencies	▪ Community involvement ▪ Information sharing and exchange ▪ Capacity utilisation		
Policy Issues	▪ Leasing policy ▪ Infrastructure development ▪ Control of effort ▪ Resource Conservation ▪ Security mechanism	▪ Resource allocation, user right, user fees ▪ Sustainability ▪ Long term welfare ▪ Endangered species Protection ▪ Improved enforcements ▪ Awareness ▪ Biodiversity conservation	▪ Community-driven development approach ▪ Promoting Enclosure/pen culture for seed rearing & production of hotel size fish ▪ Integration with other components ▪ Control of exotic species ▪ Restoration of degraded ecosystem	DoF, AFDC, NFDB, Water Resources Dept.- GoA,

9.2 Climate-Smart Business Opportunities

Climate-smart production system for aquatic food makes good sense for businesses. 'Seeing the opportunity in the crisis' should be the philosophy for the climate-smart business activities. Like any disruptive force, climate change brings many hidden opportunities for the individuals, agencies and entrepreneurs to innovate and invest befittingly in the challenging time. Investments in climate resilient action plans is rewarding when planned systematically and executed judiciously in long-term perspective. It will help in transforming and reorienting aquatic production system to effectively support the development and will ensure food security. For that it is necessary to critically examine the broad areas of production system one by one through the lenses of business opportunity. In the context of Assam, the analysis of climate-smart business opportunities in aquatic food production system is illustrated below.

Table 9.4 Analytical Framework on climate-smart business opportunities for Assam in Aquatic Food Production System

Dimensions of Resilience	Broad Target Areas	Climate-Smart Business Activity
Building Physical Resilience	Resource Management	▪ Flood Control Measures ▪ Dyke protection Measures ▪ Soil and water conservation Measures
	Transport-ation Network	▪ Construction of all-weather roads linking major production areas to markets
	Use of renewable energy source	▪ Use of solar lights and pumps in farms ▪ Use of Solar Driers for Fish drying ▪ Use of solar cooler for fish preservation & marketing
	Post-Harvest Storage, Processing & Marketing	▪ Construction of ice plant and cold storage ▪ Construction of Hygienic Wholesale and Retail Market for fish ▪ Construction of Fish Kiosks / mobile outlet ▪ Establishment of Live fish Vending Units ▪ Insulated trucks for transportation of fish ▪ Bicycle/motorcycle/auto-rickshaw with icebox for door-to-door selling
Building Biological Resilience	Genetic Up-gradation of Cultivable Species	▪ Development of Improved strains for growth and disease resistance ▪ Development of Stress Tolerant Strains of fish ▪ Import of Quality Germplasm
	Quality Seed Production	▪ Establishment of Brood Banks for commercially important species ▪ Establishments of Nucleus Breeding Centers ▪ Development of seed rearing clusters
	Species Diversification	▪ Promoting the hardy species for aquaculture ▪ Establishment of Hatcheries for new species

		▪ Brining more species under culture system
	System Diversification	▪ Use of emerging technologies like RAS, Biofloc, in-pond raceways, etc. in aquaculture ▪ Integrated farming with agri-horticultural and/or livestock components ▪ Rice-fish farming in low-lying water-logged areas ▪ wastewater-fed aquaculture (Use of low value water from dairy, brewery, food and beverage plants, silk reeling industries, etc. in aquaculture)
	Bio-safety and Bio-security	▪ Use of biotechnological tools and techniques in Aquaculture ▪ Prevention, control and eradication of infectious diseases
	Feed-based Aquaculture	▪ Establishment of feed mills (small, medium and large size) ▪ Reduction in the use of inputs having high carbon footprint
	Health Management and Disease Surveillance	▪ Implementation of quarantine protocols ▪ Development of immunoprophylaxis, probiotics, bioremediation, chemotherapeutics, etc. ▪ Surveillance against emerging pathogens and transboundary diseases ▪ Development of newer molecular-based, specific, sensitive and farmer-friendly disease diagnostics
	Adoption of Climate Resilient Practices	▪ Short Duration Fish Farming ▪ Overwintering of Seed ▪ Polyculture of carps ▪ Multiple Stocking and Multiple Harvesting ▪ Polyculture of Carps with SIS ▪ Polyculture of Carps with Freshwater Prawn ▪ Pen culture for in-situ rearing of stocking materials in *Beels* ▪ Cage culture for raising fingerling and table fish in *Beels* ▪ Production improvement in *Beel* through fish stock enhancement
	Biodiversity Conservation	▪ Measures to prevent species loss and genetic erosion. ▪ Prevention of overexploitation of wild stocks
	Ecosystem Restoration	▪ Action plan for recovery of *beel* ecosystem that has been degraded, damaged, or destroyed
Building Economic Resilience	Financing Fisheries & Aquaculture	▪ Making bank Loans available for Projects ▪ Promoting Microfinance in & Aquaculture ▪ Group-Based Credit Delivery System in Fisheries & Aquaculture
	Risk Management	▪ Extending crop insurance to cover aquaculture ▪ Group insurance to Fishermen and fish farmers
	Enterprise	▪ Promoting Start-ups in Fisheries

	Development	▪ Promoting Farmers Producer Organizations/ Companies ▪ Promoting export-oriented culture (Freshwater prawn, Indigenous Ornamental Fish, etc.)
	Certification and Accreditation Schemes	▪ Certification of Aquaculture & Fisheries inputs including seed and feed ▪ Accreditation of production units like hatcheries, Brood Bank, Farms, Service Delivery Systems, etc.
	Organic Aquaculture	▪ Promoting Organic aquaculture in the places feasible
	Income Diversification	▪ Promoting Off-farm earnings ▪ Diversity of employment opportunities
Building Human and Social Resilience	Capacity Building, Extension and Training	▪ Training on Climate Resilient Practices ▪ Conducting skill up-gradation Programme ▪ Exposure Visits to new areas ▪ Awareness camps on Climate Change Vulnerability ▪ Extending hand-holding Support ▪ Imparting Technical know-how on emerging technologies
	Nutrition/food security	▪ Local production and consumption of micronutrient dense aquatic food (SIS)
	E- marketing	▪ Promotion of E-markets and e-trading of fish and fish products
	Traceability	▪ IT enabled traceability and labelling system for tracking of fish and fish products throughout the supply chain (from farm to Fork / catch to consumer)
	Branding	▪ Exploring the opportunities of GI (Geographical Indication) tag & branding for fish and fishery products of Assam
Building Institutional Resilience	Group Activities	▪ Promotion of Farmer Producer Group, Self-Help Group (SHG), Liability Groups (JLGs)/ Cooperatives etc. in fisheries & aquaculture ▪ Cluster/ area approach in implementation of projects/activities
	Fisheries Education & Research	▪ Developing Fisheries Incubator Centres (FICs) for budding entrepreneurs ▪ Development of SOPs, BMPs and requisite regulatory frameworks

9.2.1 Implementation Modalities

For implementation of the climate-smart business plans, to the extent possible, cluster or area-based approach should be adopted. It will enhance competitiveness and facilitate economies of scale which in turn will generate higher incomes and accelerate growth. The development of clusters on the

requisite interventions should be undertaken on integrated and synchronized mode. Development of facilities for quality brood, seed, feed etc. with forward and backward linkages, expansion of grow-out areas, development of critical infrastructure, strengthening of marketing networks, etc. will be the deciding factors for achieving the long-term success in the aquatic food production system in Assam. The financial assistance in the form of loans, grants and subsidies should be made available for the climate resilient business activities. Group based credit delivery system, structured lending, risk insurance, digital transaction services, etc. will help in creating business friendly environment. To have greater adoption rate, it will be prudent to have 'value chain approach' where each activity is centred on the local communities and the natural environmental setting. A risk management tool with the abbreviated name ADAPT (Analyze, Develop, Assess, Prioritize, and Tackle) may be used for climate-smart businesses. It is basically a conceptual framework inspired by good risk management models. It involves five sequential steps as depicted below both in tabular and graphical forms.

Table 9.5 ADAPT as tool in Climate Resilience Framework

Step	Description	Process involved
Step 1	Analyze the issues	Identifying the issues which need resilience in the face of climate-related impacts
Step 2	Develop an internal strategy	To develop strategy and mobilize the right team to address the climate resilience
Step 3	Assess risks and opportunities	To assess the areas in the value chain where opportunities to build climate resilience or invest in emerging market opportunities exist
Step 4	Prioritize actions	To identify and prioritize the measures to build climate resilience in the value chain
Step 5	Tackle actions and evaluate progress	To implement actions to build climate resilience in the value chain, and to evaluate and monitor the effect of the actions over the time

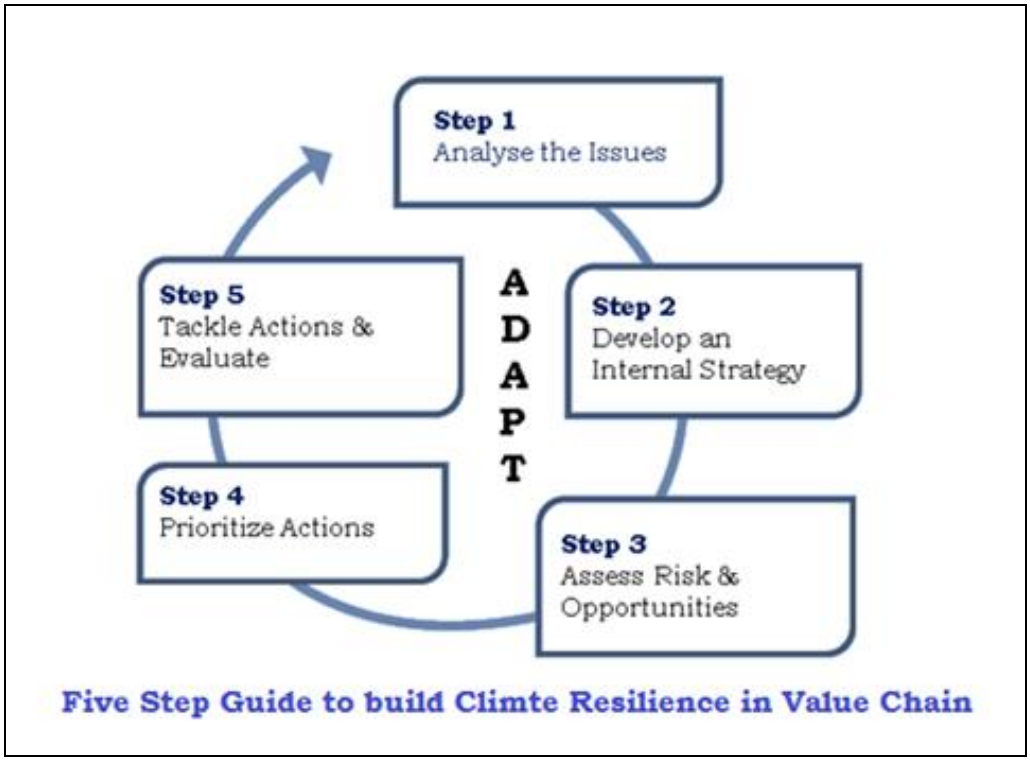


Figure 9.2 Infographic on steps to build climate resilience in value chain

9.3 Nutrition-Smart Aquatic Food System

Having enough food to eat does not imply adequate nutrition. To have good nutrition, people need to consume macro and micro nutrients from a range of foods like staple crops, fruits and vegetables and animal-sourced foods like fish, meat, eggs, milk, etc. Therefore, food production for nutrition has increasingly become a key intervention area for the second Sustainable Development Goal (SDG 2 : Zero hunger). This is a shift from contemporary food production systems, which mainly focus on increased calorie production, to nutrition-smart production systems that deliver a healthy diet to people. If local food systems don't have the capacity to produce diverse crops due to the negative impacts of climate change, the families without the means to purchase variety of foods, are at the risk of nutrition deficiency. Especially, the women and children in rural households are more vulnerable to nutritional deficiency under such situation. There is no denying fact that fish is a food of excellent nutrition, providing high quality protein, omega-3 fatty acids and a wide variety of vitamins and minerals. Even in small quantities, fish can have a significant positive impact by complementing the essential amino acids that are often present in low quantities in vegetable-based diets. The small Indigenous Species (SIS) of fish are generally considered as nutrient-rich and offer big nutritional benefits, especially for women and children. Regular eating of small species like mola keeps pregnant and lactating women healthy and makes kids smart and strong. The period from

the start of a woman's pregnancy to her child's second birthday (total 1000 days) offers a unique window of opportunity to shape healthier and more prosperous futures and help break the cycle of poverty. In this context, the climate-smart aquatic food production system may come to the rescue as an approach to transform and realign the system to support both food and nutrition security. Therefore, the climate resilient technology should ideally have component to address the issues pertaining to nutrition sensitivity. Farmers, fishers and other stakeholders should be sensitized and encouraged to adopt the practices that reduce the climate-induced risks and at the same time promote the environmentally sustainable aquatic food production and availability of nutrition-rich foods. A list comprising of nutrition-sensitive interventions in the setting of Assam is illustrated below.

Table 9.6 Interventions for Nutrition-Smart Aquatic Food System

Domain	Nutrition-Smart Interventions
Production System	▪ Small-scale Integrated farming System for production of diverse foods (integrating rice-fish, livestock-fish, vegetable-fish etc.) ▪ Farming system leveraging local biodiversity of high nutrient value (*e.g.*, promoting culture of indigenous varieties of small fish in local ponds, ponds dug in fallow land using MGNREGA fund, etc.) ▪ Promoting peri-urban fish cultivation for the supply of fresh and live fish to urban population ▪ Popularizing the concept of nutrition pond at household level to culture of wide range of fishes including small species for the consumption of family members and local people.
Post-harvest Handling, Storage & Processing	▪ Use of nutrition-smart processing techniques like fermentation, solar drying of fish, etc. ▪ Processing fish in ready-to-cook and ready-to-eat forms depending on local preference and targeted age group ▪ Promoting value added fishery products like fish chatny, fish pickle, fish chunk (like Soya chunk), fish powder, etc. ▪ Fish quality maintenance through good post-harvest handling and transportation ▪ Promoting the trade of live fish for table purpose.
Fish preparation, consumer preference and creating demand	▪ Education on role of fish in human nutrition, hygienic fish handling, etc. ▪ Campaign promoting fish as healthy diet ▪ Conducting fish festivals showcasing recipes of fish dishes (both traditional and popular dishes) and proper cooking methods to preserve nutritional values ▪ Popularizing small indigenous fish among vulnerable groups of pregnant and lactating women, infants, children, etc.

	▪ Incorporating fish as nutritional supplement in Government-aided schemes including Integrated Child Development Services (ICDS) and Mid-day school meals.
Fish Trade and Marketing	▪ Increase trade in fresh and live fish (strengthening rural-urban linkage, facilities for live-fish transport) ▪ Promoting nutrition-sensitive value chain approaches (adding value to local species and varieties) ▪ Improving fish composition data and linking information with trade and marketing strategies ▪ Clear and easy-to-read nutrition labelling in fish products

9.4 Gender Dimensions in Climate Change Vulnerability

Climate change affects women and men differently. In many contexts, women are more vulnerable to the negative effects of climate change than men. Women face particular vulnerabilities resulting from cultural norms and their lower socioeconomic status in society. Women's domestic roles often make them more dependent on the natural resources and surrounding environment. In the rural setting of Assam, women are more vulnerable as they are highly dependent on local natural resources for subsistence. In addition, they face social, economic and political discriminations that limit their coping capacity. The IPCC Fifth Assessment Report provides evidence for an increase of gender inequalities and differential vulnerabilities as a result of climate induced events like flood etc. In social setting, women are not generally taught the survival skills like swimming, climbing, etc. meaning they are more likely to suffer in natural disaster. Again, during and after these hazards, women are burdened with increased care for children, the sick and old in addition to other household duties. Climate change often results in out-migration of men. This leaves women with an increased work-load at home. Women also tend to sacrifice their food for family members during food scarcity, leaving them more vulnerable to health and psychological damages.

Nevertheless, it is important to remember that despite women being more vulnerable to climate change, they are the effective agents of change in adaptation and mitigation action plans. Every climate change action plan should embrace the targets of gender-centric Sustainable Development Goals; *i.e.,* SDG 5-gender equality and empowerment of all women and girls, and SDG 8-decent work and economic growth. In the context of aquatic food production system in Assam, women play critical role both in culture and capture fisheries that are often neither recognized nor supported. Women are more involved in small-scale production, post-harvest processing, value addition and marketing. But when the activity intensifies and scales up, women tend to be displaced to the low-paid, low-grade work.

9.5 Gender Analysis in Fish Value Chain

Gender analysis refers to the methods and tools used to understand the relationships between men and women, their access to resources, their activities, and the constraints they face relative to each other. Before going in depth, it is important to know some commonly used, yet confusing terminologies like gender equality, gender equity, gender neutral, gender blindness, gender responsive, gender discrimination, etc. 'Gender equality' means equal treatment or outcomes for women and men; while 'Gender equity' is the process to achieve gender equality. 'Gender neutral' is a policy or an action not specifically aimed at either women or men and is assumed to affect both the sexes equally. 'Gender blindness' means ignoring the different roles, responsibilities, capabilities, needs, priorities, etc. of women and men. 'Gender responsive' refers to outcomes that reflect an understanding of gender roles and inequalities. 'Gender discrimination' denotes disadvantageous treatment based on gender.

The gender analysis in fish value chain describes the role of gender in the different nodes of activities associated with aquatic food production system. It can be discussed in three sections; namely the activity profile, the access and control profile, and the analysis of factors and outlook. Activity profile mainly focuses on what men and women do, and where and when these activities take place. The access and control profile clarify on who has access to and control of resources and decision making. The analysis of factors and outlook considers the structural and socio-cultural factors that influence the gender patterns of activity and the outlook from gender perspective. The fisheries sector of Assam requires critical gender analysis, given the vital role it plays in the socio-economic development of the state. To have a clear understanding of the issue, an attempt is made to develop gender analysis framework for fish value chain in the context of Assam.

Table 9.7 Gender analysis framework for Fish Value Chain in Assam

Value Chain	Activity profile	Gender-based Access and Control	Factors and outlook
Pond Aquaculture	**Pond Preparation:** Involvement of women is minimal, mainly handled by men. **Seed Procurement:** Mostly handled by men **Seed stocking:** Both men and women are involved. **Feeding:** Mostly women are engaged in feeding, occasionally men are also involved. **Pond management** (Application of lime & fertilizer, cleaning of dyke, sampling, routine maintenance, etc.)**:** Mostly men are involved in pond management of large-scale farming that are run on commercial scale. However, women play a prominent role in pond management of household level farming. Women generally do light work, while men do heavy work. **Harvesting:** Men are in involved in dragging /casting nets during harvesting as it required physical strength. Women are involved in end-harvesting, done by dewatering the pond.	Gender inequality exists in the access to and control over the on-farm assets and other facilities. Women have inadequate access to and control over the key assets such as ponds, capital, skills, technologies, extension services, etc. which are critical to secure livelihoods.	Gender equality in control over on-farm assets can lead to greater productivity. Enabling women to fully engage in aquatic food production system with equal right and dignity can boost production, reduce poverty and enhance nutrition security. Demographic factors, including household composition and household headship; ethnicity, religion, cast, etc. act as key dimensions shaping the women's role in fisheries.
Beel Fisheries	Active fishing is generally undertaken by men, while a small percentage of women do take part in low energy shallow fishing using traditional traps and gears. The tribal population of the state relishes upon the gastropods and bivalves as a delicacy in their food. Generally, women are engaged in collecting them from *beels* and other water bodies; and sell them in local markets. They are also engaged in collection of aquatic plants and fruits from wetlands. Women often support men in	Mostly men are the member of fishers' cooperative societies meant for *beel* Fisheries. Therefore, women have poor access to and control over the *beel* fisheries. Women often earn less than men as they are engaged in unpaid work and lower-return work. Fishermen are often addicted to alcohol and	The productivity from *beel* fisheries can be enhanced through culture-based capture fisheries with greater participation of women.

	professional tasks, *i.e.,* drying of nets, selling of fish etc.	other intoxicants, and sometime abuse women.	
Integrated Fish Farming (Livestock-fish, Rice-Fish, etc.)	Women play a major role in livestock rearing like feeding, cleaning of animal sheds, etc. In areas inhabited by scheduled caste and scheduled tribe people, the rural women folk are engaged with pig raising, poultry and duck rearing along the pond dykes. Likewise, women play major role in rice cultivation operations such as transplanting, weeding and harvesting. The integrating fish farming with livestock, rice cultivation, etc. enhances the labour absorption potentials of women.	Women have access to and control over the activities associated with integrated fish farming. It is socially acceptable and financially rewarding for women.	Focus should be on the operational efficiency of the system through better utilization of space and labour, recycling of nutrients and higher production.
Ornamental Fish production	Mostly women are engaged in ornamental fish breeding and seed rearing activities. Along with men, women are involved in fabrication of aquarium. Women are involved setting up of retail outlet for sale of aquarium, accessories and ornamental fishes in urban areas.	Women have fair access to and control over the activities associated with ornamental fisheries. Same can be strengthened further.	Ornamental fisheries should be promoted through SHGs and Cooperatives in which the presence of women is predominant.
Post-Harvest Processing	Women are mostly involved in post-harvest processing activities using methods like sun drying, smoking, salting, fermentation, pickling of fish, etc. As the water bodies of Assam harbours lots of small fishes, these can be used for preparation of fish pickle.	The low level of literacy amongst women is a hindrance to the adaptability of a technology. They are able to learn techniques easily when transmitted visually and adopt them when offered with handholding support.	Propagation of post-harvest methods relevant to local situations will generate employment among the rural women.
Marketing and Trade	Unlike the maritime states, in Assam, the representation of women is low in fish marketing and trade. Women seldom procure their fish directly from landing centres where they are likely to participate in daily auctions of the catch. Instead, the women vendors buy from traders and	Many fish markets lack access to basic market facilities like clean toilets, hygienic running water and adequate waste disposal measures. Lack of such facilities prevents women to engage in	There is a need to develop women-supportive marketing infrastructure in order to

	merchants or buy from the wholesalers for resale at retail or local markets. Women also carry out value addition by species-wise sorting, size-grading, cleaning and ice-storage of the harvested fish. Women are not engaged with door-to-door marketing of fish and rely on the male vendors for the sale.	their occupation in a dignified manner.	involve more women in the marketing chain.
Fish Consumption (Social, cultural and religious beliefs)	There are certain social, cultural and religious beliefs/restrictions that affect the fish is distributed among family members. Due to social norms, even though pregnant and lactating women have high nutritional needs, more fish may be served preferentially to others in the family. On certain days in the week and during some fasting periods, the women may not eat fish on religion grounds.	There is an intra-household disparity in sharing of fish within the family members for consumption. Due to the social, cultural and religious beliefs/norms, women have less access to fish for consumption.	Need for analysis of appropriate strategies to improve the consumption of fish amongst the women, especially the pregnant and lactating women.
Entrepreneur-ship Develop-ment	Women are generally associated with less-profitable nodes of fish value chains. These jobs involve low pay. However, in changing scenario, women may initiate start-up enterprises in the areas like small-scale feed manufacturing, ornamental fish breeding and rearing, value-added fishery products, etc.	Women have almost no access to and control over the enterprises in fisheries. The traditional beliefs give women a secondary social role and generally not welcome in establishing business enterprises in fisheries.	Women can participate in the formation of Farm Producer Organizations (FPOs), Joint Liability Groups (JLGs) etc. to make effective use of bank finance /microfinance to initiate start-up enterprises in fisheries.
Financial Management, Planning and Decision Making	In current setting, financial management is mostly rest on men. Though planning is done both by men and women, the decision-making lies mostly on men. Though women work in homestead ponds, they have little decision-making power over these ponds.	Women lack access to credit facilities as the ownership of land and other productive resources mostly belongs to men.	Formation of more women Self Help Groups (SHGs) and Joint Liability Groups (JLGs) will provide credit facilities to women and can become a powerful

			tool in improving the livelihoods.
Fisheries Research & Education	There is a lack of gender responsive research and gender mainstreaming course in fisheries research and education. Sensitisation on gender issues is necessary so that men do not disregard the needs, interests, and concerns of women. Women should be also aware of their needs and participate in different activities to gain equal benefits.	Women have less access to and control over the technologies used in fisheries as some of these are not women-friendly.	Advancements in fisheries sector so far have focused on men as the primary stakeholder. Now time has come to bring change in this outlook.
Policy Development and Service Delivery	There is a need for more women-centric policy solutions in Fisheries. The gender gap in aquatic food production system can be bridged through innovative policies and interventions ensuring greater participation of women. Women-friendly service delivery mechanism will facilitate the sector's overall growth. Information & Communication Technology (ICT)-enabled Support Service will act as an interface between Government and stakeholders.	Barring ornamental fisheries, there is no much access and control for women in fisheries sector due to inadequate policy support. There is a need to launch some schemes exclusively for women.	Gender responsive outlook favouring women in the policies, schemes and programmes in fisheries. Women participation in policy framing will be crucial.

10 Climate Resilient Strategies for Aquaculture & Fisheries

10 Climate Resilient Strategies for Aquaculture & Fisheries

Climate change is affecting the physical, chemical and biological processes of aquatic food production systems. It is potentially impacting the overall production, income and livelihoods of the dependent communities, food security and overall, the sustainable development. In the study, the respondents shared their varied experiences and the efforts taken by them on the ground towards climate resilience. Upon critical analysis of prevailing situations, it is clear that the strategies on climate change adaptation in aquatic food production system need to be designed based on three fundamental aspects: (i) the prudent use of climate information services, (ii) adopting climate-resilient technologies and practices to support sustainable livelihoods, and (iii) an ecosystem approach to the production system. In order to select and implement the strategic measures and the technical options, following considerations are necessary.

- Climate Information Services (CIS) should provide the science-based and user-specific information for managing risks and exploiting opportunities created by climate variability and change, thereby helping society to become more resilient in coping with the increasing impacts of climate change.
- To promote sustainable livelihood, the people should be involved in the choice of adaptation measures comprising of climate-resilient technologies and practices and the choices are made to be compatible with their livelihood objectives, strategies and assets.
- Need to have Ecosystem-based Adaptation (EbA) which involves a wide range of ecosystem management activities to increase the resilience and reduce the vulnerability of people and the environment to climate change.

The above concept and practice need to be integrated into plans and projects following a sound adaptation pathway. For this, the available adaptation options need to be checked using feasibility assessment and cost-benefit analysis in local context. An infographic on adaptation pathway is proposed below for aquatic food production system in Assam.

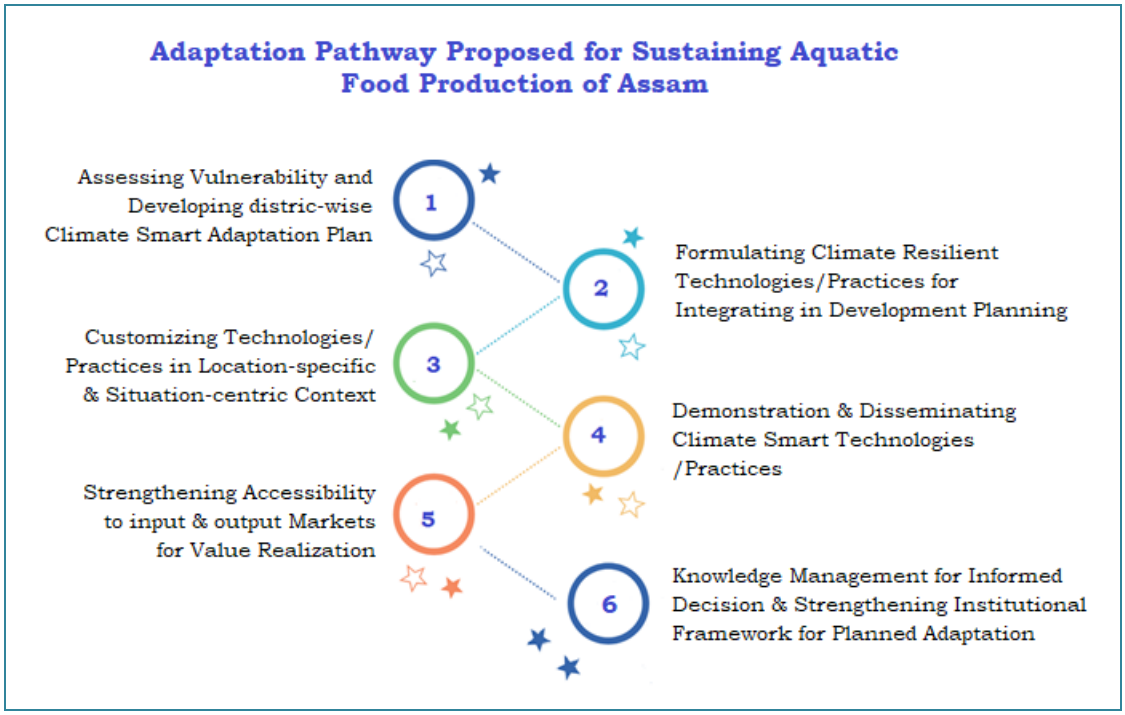


Figure 10.1 Infographic on adaptation pathway for sustainable Aquatic Food Production System

10.1 Developing Climate Information Services (CIS)

Climate Information Services (CIS) are meant to provide the science-based and user-specific information for managing risks and exploiting opportunities created by climate variability and change, thereby helping society to become more resilient in coping with the increasing impacts of climate change. As we know, the aquatic food production system is highly vulnerable to the impacts of climate variability and change. Sudden temperature fluctuations exceeding the tolerance level may cause mortality in fish. Dry and cold spells can trigger disease outbreaks. Erratic or intense rainfall may lead to losses in production. These are just some of the challenges farmers/fishers are likely to face in a changing climate situation. Therefore, institutionalization of CIS can help farmers and fishers alike in taking informed decision well in advance to manage the risks associated with climate variability and extreme weather events.

Considering the extensive aquatic resources of Assam, the climate impacts on aquatic food production and the socioeconomic vulnerability of small-scale fish producers, it is high time for the state to focus on developing reliable CIS which will provide timely and contextualized decision support to the small-scale farmers and fishers. The information received from field survey revealed that high temperature, prolonged cold spell, heavy rainfall, flood and dry spell events are the major climatic phenomena affecting year-round production operations including pond preparation, seed stocking, grow-out management, and harvesting. Based on the information received through field surveys, key informant interviews, and literature review; an attempt was made to develop a framework for 'Climate-Responsive Decision Making'. It is aimed at reducing

associated risks in aquatic food production and primarily based on temperature and rainfall thresholds.

Table 10.1 Framework for Climate-Responsive Management Decisions in Aquatic Food Production

Climate variability	Affected Areas of Operation	Potential Impacts	Climate-Responsive Management Decisions	Intendent Result
Temperature rise	Pond water quality	▪ Increased rate of decomposition ▪ Decreased pH level ▪ Lowering of dissolved O_2 ▪ Increase in harmful gases like NH_3 and H_2S	▪ Lime application ▪ Water Pumping into the Pond ▪ Aeration of pond water ▪ Use of aqua-chemicals, if needed	▪ Improved pond water quality ▪ Reduced risk of fish disease
	Feeding	▪ Reduced digestion capacity ▪ Less food intake	▪ Reduced feeding rate ▪ Applying feed in morning hours when temperature is low	▪ Reduced climate-induced losses
Dry spells	Seed stocking	▪ Lack of sufficient water in pond	▪ Supplying ground water using pumps ▪ Limiting seed stocking ▪ Delayed stocking	▪ Reduced climate-induced risks
	Pond water quality	▪ Rise in water temperature ▪ Disease outbreak	▪ Manage ground water supply using pumps Increase in pond depth ▪ Reducing fish stock density ▪ Partial harvesting	▪ Reduced climate-induced losses
	Feeding	▪ Less food intake	▪ Reduced feeding rate	▪ Reduced climate-induced losses
Heavy rain	Pond water quality	▪ Decreased dissolve O_2 level ▪ Decreased pH level ▪ Sudden drop in water temperature	▪ Aeration of pond water ▪ Application of oxygen enhancing chemicals	▪ Reduced mortality rate
	Feeding	▪ Reduced food intake	▪ Reduce / Stop feeding	▪ Reduced climate-induced losses
	Seed stocking	▪ High mortality rate	▪ Delay seed stocking	▪ Reduced climate-induced risks

	Flooding	Fish escape	▪ Erecting the net fencing around the pond dyke ▪ Repairing of damaged part of the dyke	▪ Reduced climate-induced risks
Cold spells	Pond water quality	▪ Drop in water temperature, especially in night hours ▪ Increased pH level	▪ Exchange water from borewell ▪ Restrict lime application	▪ Reduced physiological stress on fish
	Abnormal fish behaviour	Fish floating in surface water	Reduce stock by partial harvesting	▪ Reduced climate-induced losses
	Feeding	Less food intake	Reduce feeding	▪ Reduced climate-induced losses

10.2 Coping measures against Floods

Assam with its vast network of rivers is prone to frequent flooding. The flood prone area of the state as assessed by the Rastriya Barh Ayog (RBA) is 3.105 million hectares against the total area of 7.852 million hectares (39.58 % of the total land area of Assam as against the national average of 10.2 %). It signifies that the flood prone area of Assam is about four times the national mark of the flood prone area. Aquatic food production system in Assam has to cope with changing climatic conditions. Farmers and fishers are currently tackling the problems through short-term coping measures which need scientific improvements to give long-term relief. This is possible through formulation of climate-resilient adaptation strategies that will reduce the adverse consequences. Few suggested coping measures against flooding are narrated with pictorial illustration for easy understanding.

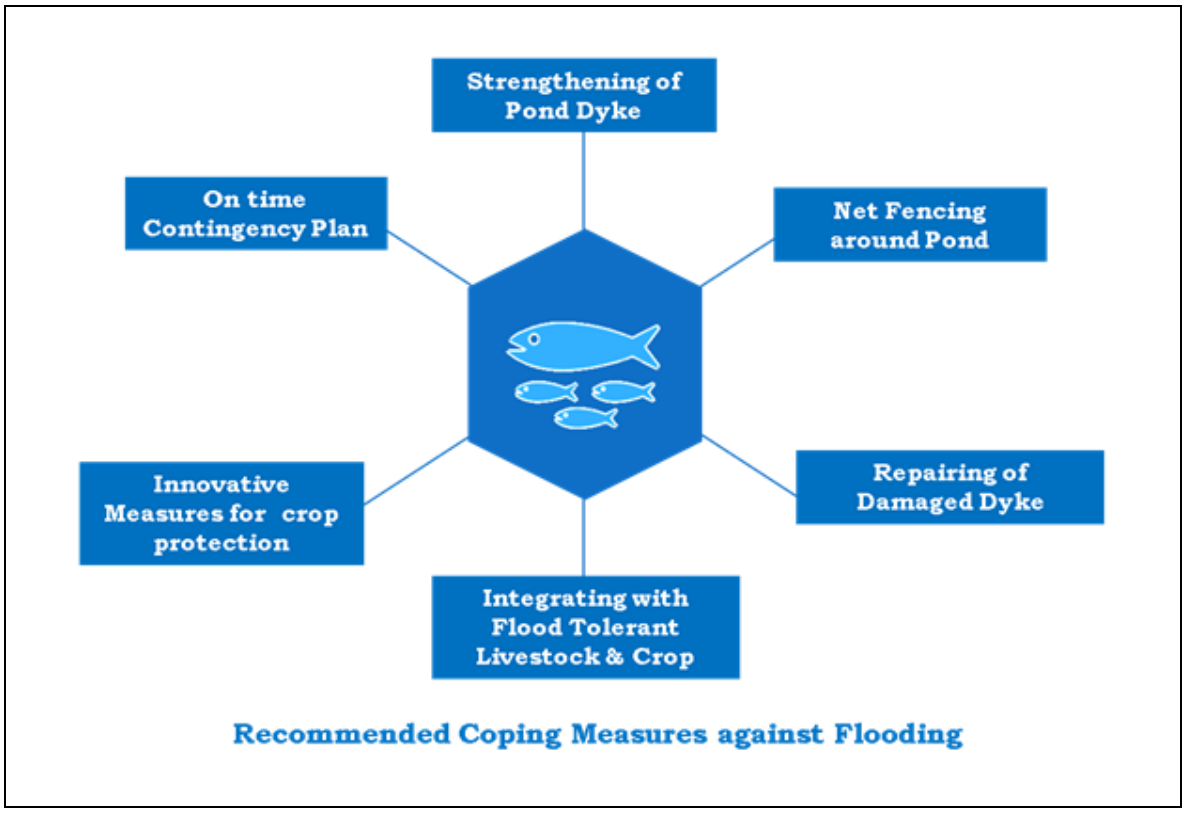
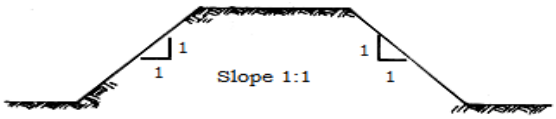
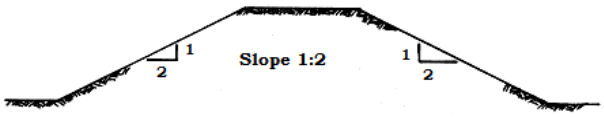
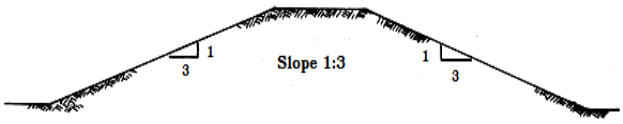
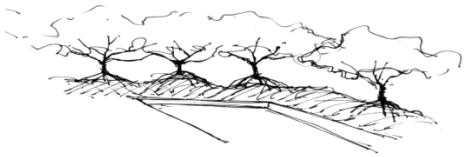


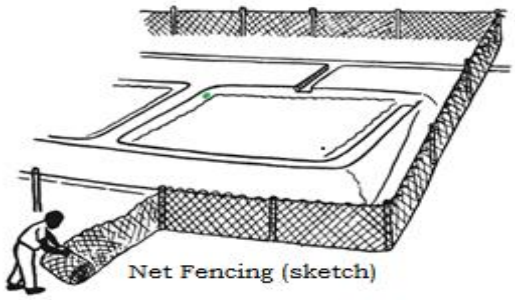
Figure 10.2 Infographic on recommended coping measures against flooding

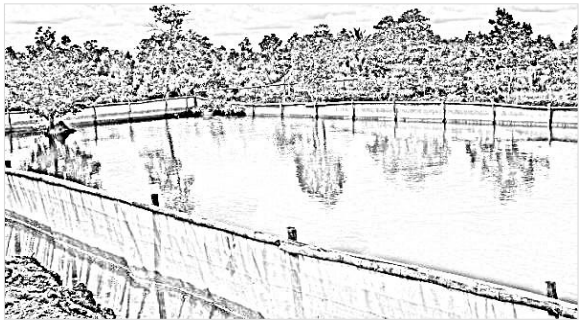
Dyke height should be increased for the ponds located nearer to the river and for the low-lying areas. Height of the dike should have a free board of 0.6–0.7 meter above the desired water depth. For the flood prone areas, the dyke height should the more than 0.5 meter above the maximum flood level for protection. Apart from dyke height, slope of the dyke is also important as it plays a vital role in giving the dyke its physical stability and to check erosion. Slope also depends on the type of soil. Good clayey soil is very good for pond

construction. Dykes with steep slopes are always subjected to erosion and require higher maintenance cost. Gentle slopes for the dykes give physical stability against flood. The crown (top) of the dyke should be more than 1 meter. It is advantageous to plant grass on the slope of the dikes to control soil erosion. Plantation on the top of the dyke will further strengthen the dyke. This will also give additional income to the farmers through agricultural crop.

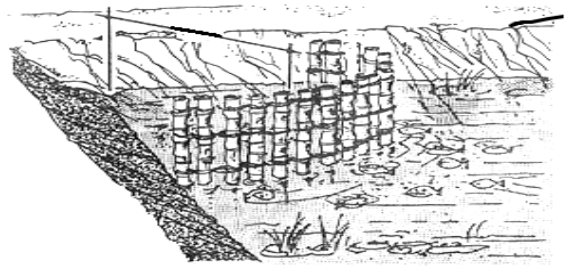
Slope of the Fish Pond Dyke	Feature
	Steep Slope: less stable dyke, vulnerable to damage by flooding, prone to erosion by water wave, use less area for dyke.
	Medium Slope: Fairly stable dyke, less vulnerable to damage by flooding, less prone to erosion by water wave. Occupies more space for dyke construction.
	Gentle Slope: Very stable dyke, least vulnerable to damage by flooding & erosion. Occupies much more space for dyke and thus create scope for vegetable cultivation on the slope of the dyke.
	Plantation on the top & grass on the slope of dyke will give better stability and protect from erosion.

- For the farmers who keep fish stocks throughout the year in the ponds which are prone to floodingshould think of erecting the net fencing around the pond dyke to prevent fish stock from escaping during flooding.

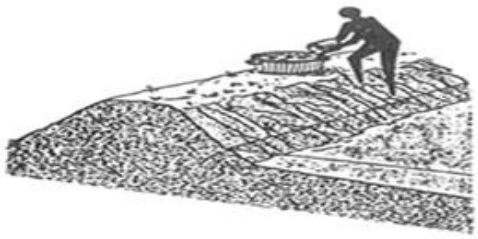

Net Fencing (sketch)



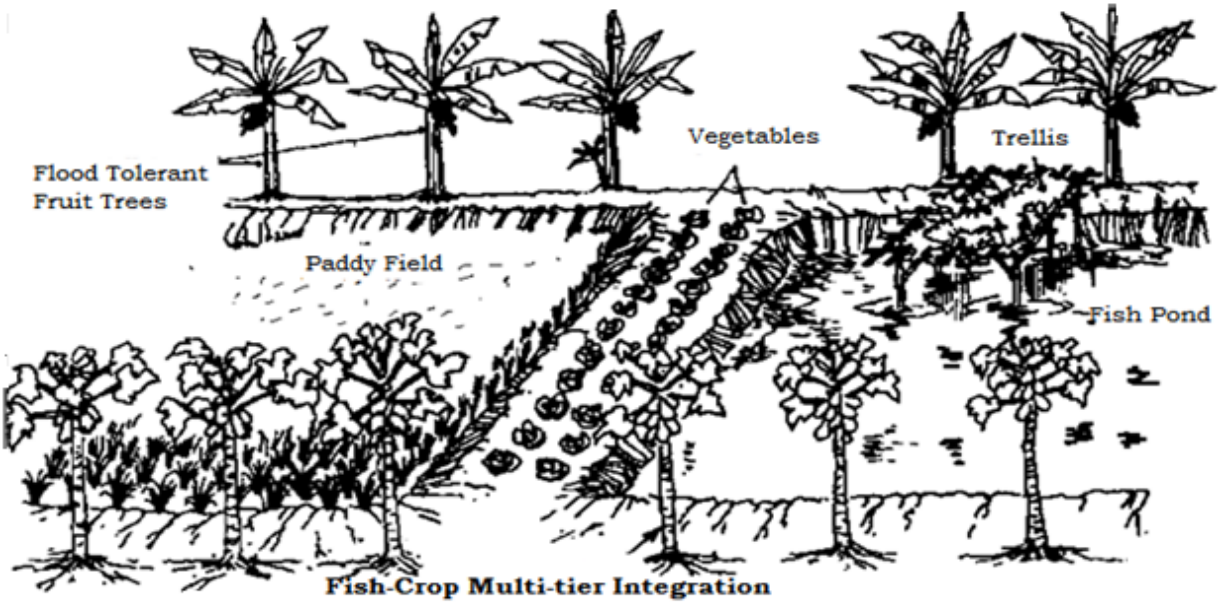
- Repairing of damaged dykes and construction of new dykes wherever necessary should be taken up well in advance to protect the areas from flood water.



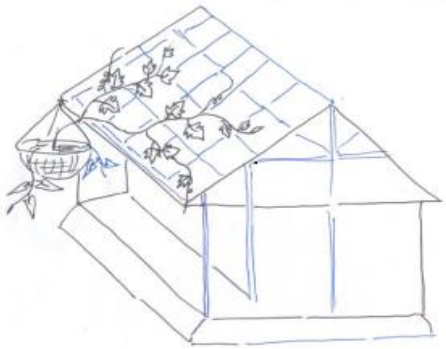
Repairing of damaged dyke



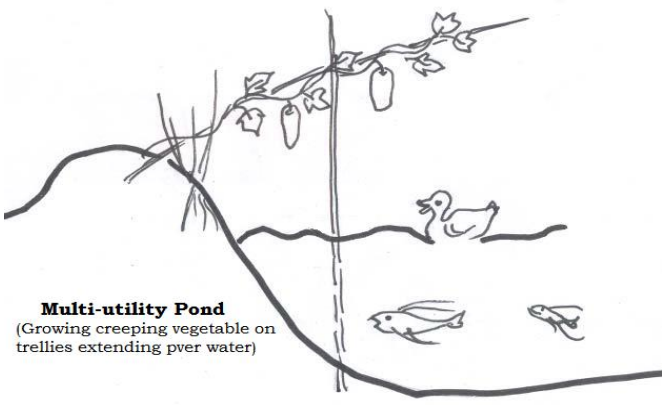
- Integrating fish farming with flood tolerant livestock like duck and flood tolerant crop will give more employment generation, better economic returns and less risk. This can be achieved through land shaping, reclamation, re-excavation of water sources including step-cutting or terrace farming on inward-slopes of the ponds. These steps or terraces can be used for vegetable cultivation even during dry periods. Trellis over the pond water surface can be used for creeping vegetables.



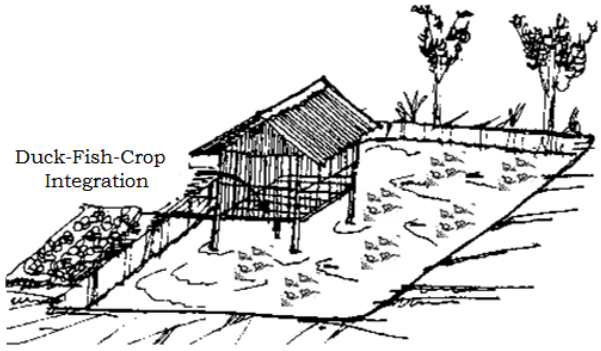
Fish-Crop Multi-tier Integration

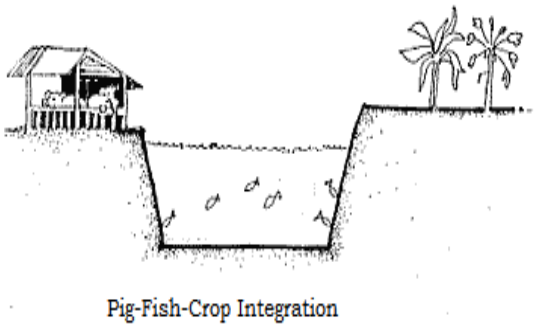


Basket with Creeping Plant hung
from roof Corner

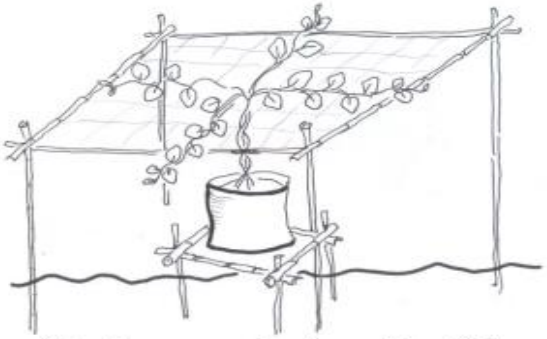


Multi-utility Pond
(Growing creeping vegetable on
trellies extending pver water)



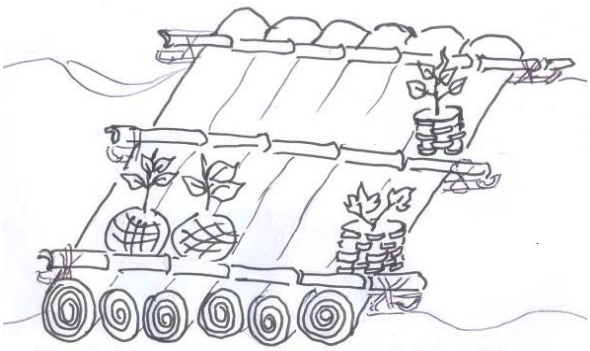


Pig-Fish-Crop Integration

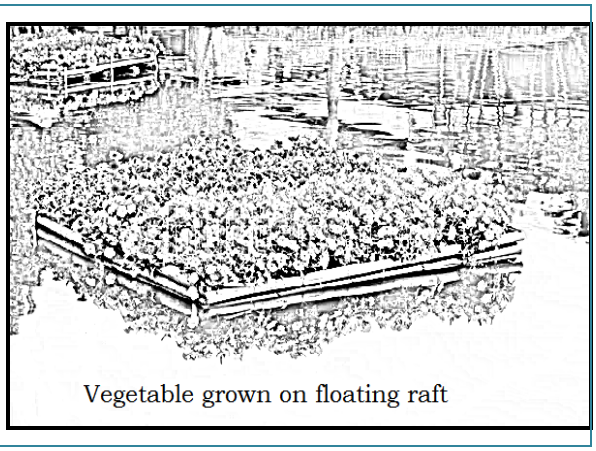


Planting on raised sac (sketch)

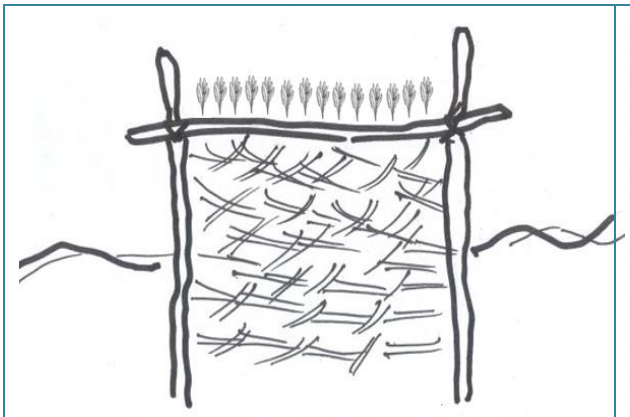
Planting on raised sac



Vegetable grown on floating raft (sketch)



Vegetable grown on floating raft



Vegetable on bed raised with weeds

Vegetable bed in Beel

- Farmers and fishers should keep a close watch on mass media / local media for prompt information on flood, cyclone, depression, *etc.* and should take appropriate precautionary measures.
- Farmers and fishers should be imparted training programme on climate change adaptation strategies and disaster preparedness. This will create awareness among the stakeholders on the various climatic issues with causes and impact, and leading to the adaptation of various resilient technologies at community level.
- Farmers may be advised to take crop-weather insurance wherever available.
- For climate induced risks like flood, drought, cyclone, etc., Government should prepare time bound contingency plan so that the action can be initiated at the very onset.

Table 10.2 Flood / Drought Hazard Mitigation Framework for Fishery Dept.

Category	Action plan for flood / drought hazard mitigation
Preparedness	▪ Mapping of fish farming areas vulnerable to flood / drought ▪ Identifying the risk spots for flood hazard ▪ Development of manual for construction and maintenance of pond embankments for flood prone areas ▪ Imparting training to Departmental staff and fish farmers on the precautionary measures and the preparedness plan to prevent/ reduce loss in farming due to flood/drought ▪ Preparation of flood/drought contingency plan from Fishery Dept.
Prevention & Mitigation	▪ Increase public awareness on flood/drought hazard and mitigation possibilities ▪ Introduce the scheme for fish crop insurance ▪ Improve the drainage system in flood prone areas and water conservation measures in drought prone areas ▪ Advocate flood resilient farming practices like short duration fish farming, sack cultivation of vegetable on pond dyke, stocking of advanced fingerling, overwintering of fish seed, etc.
Alert and Warning	▪ Disseminate alert and warning mechanisms of Flood Early Warning System (FLEWS) to farmers and fishers ▪ Take necessary precautionary actions, including moving of farm equipment / tools / inputs to safer location ▪ Advice to harvest the fish stock to the extent possible. This will reduce the loss which otherwise could be higher. ▪ In case of disease outbreak, determine the source of disease and take measures for effective control and to protect the standing crop
Post-Disaster Response	▪ Assessment of damage occurred to fish crop in flood/drought ▪ Resource augmentation and mobilization to cater response needs ▪ Estimation of needs to recover from flood/drought ▪ Rapid survey of damage and provide immediate relief

Rehabilitation	▪ Restoration / reconstruction of damaged infrastructure/ facilities ▪ Financial package / assistance to the affected farmers for crop loss ▪ Socio-economic impact assessment and extending post-disaster psychosocial care

11 Conclusion

11. Conclusion

Climate change is a global challenge and India has also taken this challenge as a national priority. While the sectors like energy, industry, forestry, etc. have the potential to mitigate greenhouse gas emissions; other sectors like agriculture, animal husbandry, fisheries, biodiversity, etc. offer opportunity to adapt to climate change. To address the issues, all the states including Assam have formulated 'State Action Plans on Climate Change' and are implementing the action plans at state level to tackle the problems. The projections for Assam clearly suggest that the state is likely be impacted negatively by climate change and the aquatic food production system, being a climate-sensitive sector, is going to be impacted the worst. As such, this sector in the state is already facing the stresses like resource degradation, biodiversity loss, pollution, etc. The emerging climatic issue will thus make the already sensitive sector even more vulnerable. It is imperative that the vulnerable communities of farmers and fishers enhance their resilience to deal with the climate variability and change. This is best achieved through adaptation strategies to climate change and APART project is doing exactly the same. For the project, only the Climate resilient technologies and practices with local relevance are being selected for demonstration and dissemination. Currently, nine such interventions are at different stages of implementation. In this study, their performances in the field and feedbacks from stakeholders were collected and analysed. All interventions are showing positive results in increasing the production and protecting the yield from the climate-inducted risks. Farmers and fishers are enthusiastic about the project and are actively participating in successful implementation. The implementing agency and collaborating partners are taking coordinated efforts to bring visible impact in the sector through this project. To draw a meaningful conclusion to this study, the overall assessment of the project is attempted using 'SWAN Analysis' (S-Strengths, W-Weaknesses, A-Achievements and N-Next Steps).

Box: 11.1 SWAN Analysis of APART-Fishery Project

S-Strengths

- Wide geographical coverage that includes 15 potential districts (undivided) of Assam
- Promoted cluster-based production and enables enterprise development
- Focus on the interventions those are based on climate resilient technologies/practices
- Robust institutional and implementation arrangements with effective Management Information System (MIS)

- Knowledge partnership with WorldFish to bring in international technologies and best practices

W-Weeknesses

- In many cases, the project areas are prone to climate-induced threats like floods, droughts, etc.
- In general, there is an absence of quality certification mechanism for seed and feed
- Overall, there is a lack of bio-security infrastructure in most of the farms and hatcheries
- Poor post-harvest value addition
- Limited export potential

A- Achievements

- Able to demonstrate the usefulness of climate resilient technologies and practices amonst the smallscale farmers and fishers, and thereby paving the way to their wide adoption.
- Most of the interventions have reported increase in production and have shown resilence against climate-induced threats, especially in vulnerable areas.
- Though promoted as climate resilient technologies, these are gaining popularity as a general strategy to increase production.
- Contributing to the nutritional security and greater dietary diversity for the local communities.
- Institutional arrangements between farmers, College of Fisheries and ARIAS Society facilitate the better adoption of the technology.
- Last but not the least, the participating farmers and fishers are happy with the project and have shared positive and encouraging feedbacks during survey.

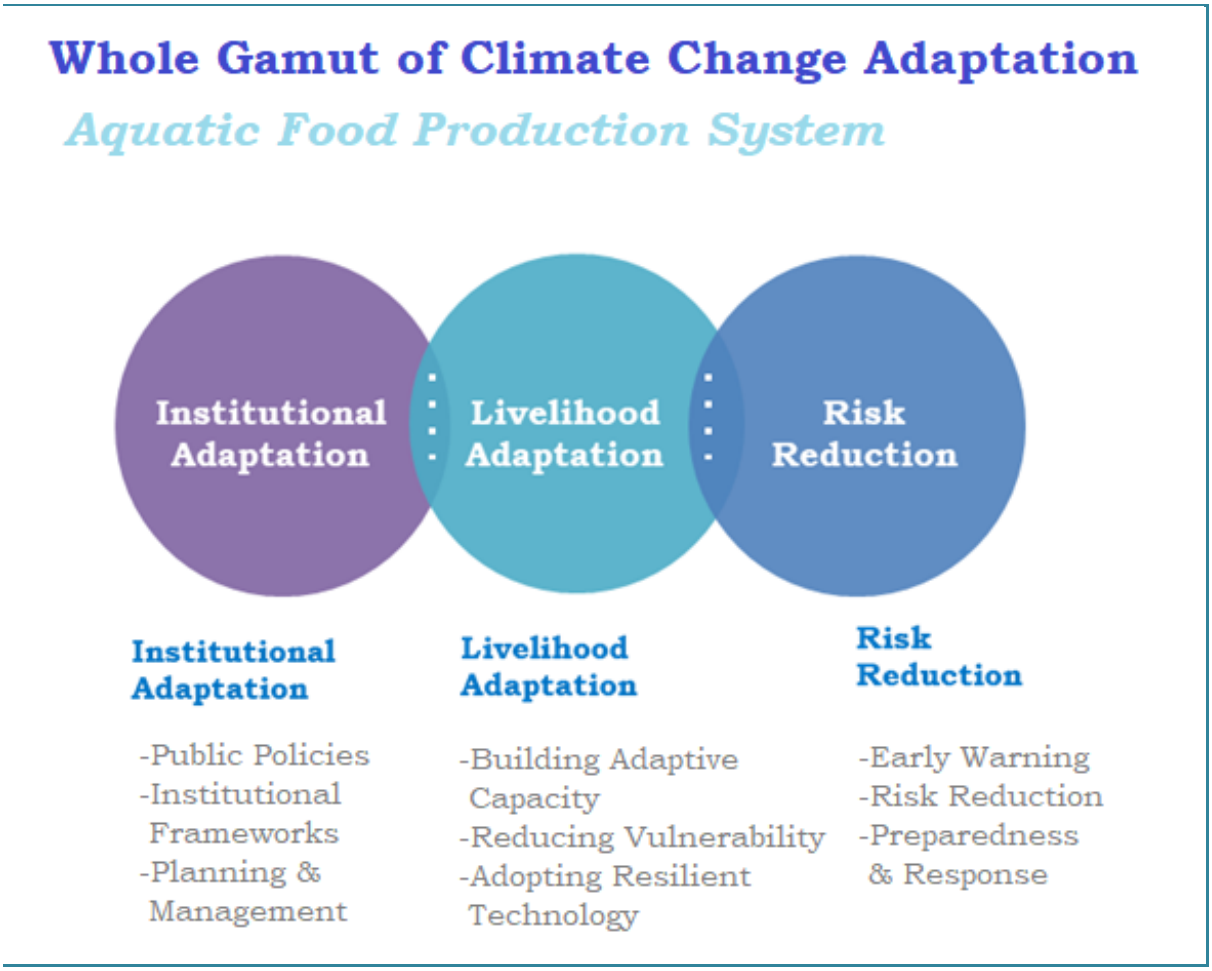
N- Next Steps

- Up-scaling the climate resilient technologies and practices in potential areas through capacity building and dissemination
- Integrating farm production with value addition and processing wherever feasible
- Conducting the Farmers' programmes on judicious chemical and drugs usage
- Modification and refining of BMPs based on lesson learnt from field demonstrations
- Establishment of Information & Communication Technology (ICT)-enabled Support Service System to deliver advisory services with

reference to life cycle of species cultured, water quality, growth, health, disease diagnosis, etc.

- Support for setting up Disease Diagnostic Labs, quality testing labs for inputs, etc. in potential areas

Application of climate adaptive technologies for productivity enhancement is the focus area of APART. The results show a conclusive trend of this and stakeholders are benefitted. To enhance the relevant capacities among the practitioners and decision makers, the project has built capacity through various programmes and action plans aimed at integrating climate change adaptation into development planning at various levels. In terms of their content and format, all measures were tailored to the respective needs of the target groups. On the contrary, if climate change and other environmental issues are not accounted for in the development projects, the investments made in the sector will be at high risk. To make the story short, the core essence of adaptation in aquatic food production sector, as depicted in the below mentioned infographic, encompasses multipronged approach. *i.e.*, institutional adaptation, livelihood adaptation and risk reduction.



To sum up, the project is able to create a vibrant and positive environment in aquatic food production system of the state through various innovative activities like sensitizing the farmers/fishers on the concept of resilient practices, making the production clusters, introducing high value species, arranging seed and feed, including BMPs in routine management, spearheading the enterprise development, linking the local processors and buyers for higher value realisation, etc. The positive impact of APART is also evident from the fact that in the year 2020, the Assam state has bagged four national level awards in the fisheries sector, namely best state, best district, best Govt. organisation and best farmer from Govt. of India in 'Hilly and North Eastern' category. In last five years (from 2016-17 to 2020-21), the state has registered an impressive growth of 28.4% in fish production and a spectacular 74.11% rise in seed production. This is indeed a good beginning. There is a saying, 'good start is half done'. The good beginning of the APART project will make the long-term growth of aquaculture and fishery in Assam.
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http://www.seismo.ethz.ch/static/GSHAP (The Global Seismic Hazard Assessment Program)

http://www.unisdr.org (United Nations International Strategy for Disaster Reduction)

https://agricoop.nic.in (Ministry of Agriculture & Farmers' Welfare, Govt. of India)

https://bisa.org (The Borlaug Institute for South Asia)

https://bluesolutions.info (Blue Solutions is a global project implemented in partnership by GIZ)

https://dst.gov.in/climate-change-programme (Climate change Programme-Department of Science, Govt. of India)

https://indianculture.gov.in/rashtriya-barh-ayog-national-commission-floods (National Commission on Floods)

https://mausam.imd.gov.in (India Meteorological Department, Ministry of Earth Sciences, Govt. of India)

https://necouncil.gov.in (The North Eastern Council)

https://nfdb.gov.in/ (National Fisheries Development Board)

https://public.wmo.int (World Meteorological Organization)

https://unfccc.int (United Nations Framework Convention on Climate Change)

https://unfccc.int/Adaptation-Fund (Adaptation Fund, UNFCCC)

https://waterresources.assam.gov.in/portlets/flood-management (Flood Management Division, Water Resources Department, Govt. of Assam)

https://www.cifa.in (Central Institute of Freshwater Aquaculture)

https://www.cimmyt.org (The International Maize and Wheat Improvement Center)

https://www.enaca.org (Network of Aquaculture Centres in Asia-Pacific)

https://www.fao.org/fishery (FAO, Fisheries and Aquaculture Division)

https://www.fssai.gov.in (Food Safety and Standards Authority of India)

https://www.giz.de (The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, often shortened to simply GIZ)

https://www.irri.org (International Rice Research Institute)

https://www.iucn.org (International Union for Conservation of Nature)

https://www.nabard.org (National Bank for Agriculture and Rural Development)

https://www.wio.int (World Intellectual Property Organization)

https://www.worldfishcenter.org (WorldFish, a member of CGIAR)

Annexures

Annexure-I

Knowledge, Attitudes and Practices (KAP) Survey Questionnaire

Target Group: Aqua Farmers

Background Information

Culture and capture fisheries provide livelihoods for thousands of rural households in Assam, who are directly or indirectly involved in the production fish and its value chain. The present production from culture and capture fisheries is far below the potential productivity as well as less than the productivity achieved by some other states. Foreseeing the high potential in the sector, Govt. of Assam has launched the project "Assam Agribusiness and Rural Transformation Project (APART)" with financial assistance from World Bank in targeted districts of Assam. Fish is prioritized as one of the value chains for interventions in APART. WorldFish is providing technical support to the fishery components of the project. Application of climate resilient technologies for productivity enhancement in culture and capture fisheries is one of the project intervention areas. The current questionnaire-based survey is a part of the Government sponsored study aimed at formulating climate resilient aquaculture strategies for the benefit of the fish farmers. The information gathered will not be shared with anybody, except for in-house analysis to draw inferences. Therefore, please feel free to share your frank views and opinions.

A. GENERAL INFORMATION			
1. NAME OF FARMER :			
2. VILLAGE:	**BLOCK:**	**District:**	**Mobile No.**
3. AGE: Yrs.	**SEX:** Male / Female	**CASTE:** General / SC / ST / OBC / Muslim	
4. EDUCATIONAL QUALIFICATION: Illiterate / Literate (Class:)			

B. INFORMATION ON AQUACULTURE

5. POND DETAILS: (i) Total number of ponds: (Grow-out: ; Nursery:)

(ii) Total ponds area: Bigha (Ha.)

(iii) Nature of Holding: Own / Multiple owners / Leased Pond

(iv) Water Source: Rain water / Ground water / River / wetland

(v) Pond Type: Seasonal / Perennial

(vi) Inlet & Outlet: Present / Absent

6. TYPE OF AQUACULTURE: (i) Fin Fish *(Machh)* / Shell Fish *(chingri)* / Both

(ii) Traditional / Modified Extensive / Semi-intensive

(iii) Monoculture / Polyculture / Livestock-fish Integration / dyke cropping

(v) Number of crops in a year:

(vi) Name of Species Cultured:

(v) Aquaculture operations practiced by: □ Men only/ □ Men & women / □ Women only

(vi) Use of ponds other than aquaculture: □ Bathing □ Household chores □ Livestock bathing

C. POND MANAGEMENT

7. POND PREPERATION: (Tick which are followed)

Dewatering / Bottom Sediment removal / De-weeding / Eradication of predator / Liming / Manuring

8. STOCKING: (i) Seed Source: Hatchery / Natural

(ii) Stocking type: Single / Multiple stocking

(iii) Fish Seed size: Spawn / fry / Fingerling / Advanced Fingerling

(iv) Any naturally occurring fish species/ self recruiting fish in your pond

(Mola, Koi, Singhi, Magur, catfishes etc.)

(v) Do you prefer Tilapia for stocking at your pond?

(vi) Seed acclimatization done: Yes / No

(vii) Disinfection of seed done: Yes / No

(viii) Fish stocking rate : / bigha (/ ha)

9. SUPPLEMENTARY FEEDING: (i) Supplementary Feeding done : Yes / No

(ii) Type of feed: Rice bran & oil cake / Farm made / Branded Feed

(iv) Frequency of feeding: Daily / ____ times per week

(v) Nature of Feeding: Broadcasting / tray feeding / bag feeding

10. HEALTH MANAGEMENT: (Put Tick Mark)

(i) Common diseases encountered: Body Ulcer-EUS / Fin & tail rot / Parasites like Argulus / Mal-nutrition / Others (please specify)

(ii) Occurrence of disease (Season): Summer / Monsoon / Winter

(iii) Occurrence of disease (in growth phase): After stocking / Mid-crop / End-crop

(iv) Treatment against disease: Liming / water exchange / use of chemicals / antibiotics / Any other methods

11. HARVESTING: (i) Mode of harvest: Single / Multiple

(ii) Fish species showing best growth (in order):

(iii) Total Fish production: kg / Bigha / _____(duration)

(iv) Proportion of fish utilization (%):

Self consumption [____%] / Gift to friend & relatives [____%] / Sale [____%]

12. MARKETING: (i) Mode of marketing: At pond site / Local market / through middle man

(ii) Av. Sale price of fish : Rs. _____ / kg for fish size of _____

13. WATER QUALITY: (i) Water pH (if measured):

(ii) Av. Water colour: Green / Dark Green / Light Green / Brown / Muddy / Others

(iii) Depletion of dissolved oxygen: Occur / Not occur / Not observed

14. Do you follow biosecurity measures in aquaculture operations:

□ Netting & fencing around the pond □ Bird prevention □ Restriction of unwanted entry

15. KNOWLEDGE IN AQUACULTURE: (Tick options)

Govt. training / NGO training / from other farmers / self taught / from mass media

16. Do you a member of any SHG/ Cooperatives: Yes / No

17. Do you have ever contacted any Fisheries Extension officials for your fishery related problem: if yes, how often.

D. FARMERS' PERCEPTIONS ON CLIMATE CHANGE

18. Do you perceive the change of climate in your area? (Put Tick Mark): Yes / No

19. If yes, please share your local experience of climate changes (over the last 20-30 years):

19 (i) Temperature: Increased / Decreased / Remained same / Does not know

Observed impacts of change in Temperature (Put Tick Mark)

(a) Hotter Summer

(b) Long Summer

(c) Short winter

(d) irregularities in season change

(e) Drought

(f) Others (if any, please mention)

19 (ii) Rainfall: (Put Tick Mark) Increased / Decreased / Remained same / Does not know

Observed impacts of change in Rainfall (Put Tick Mark)

(a) Erratic Monsoon

(b) Shortening of Monsoon Season

(c) Lingering of Monsoon Season

(b) Low Rainfall

(c) High Rainfall

(d) Heavy rainfall during onset and offset of monsoon

(f) Others (if any, please mention)

19 (iii) Cyclone: (Put Tick Mark) Increased / Decreased / Remained same / Does not know

Observed impacts of change in Cyclone (Put Tick Mark)

a) Increased frequency in cyclones

b) Decreased frequency in cyclones

c) Increased intensity of cyclones

d) Decreased intensity of cyclones

e) Heavy downpour during cyclone

f) Loss of Life

g) Loss of crop

h) Lossof property

i) Others (if any, please mention)

19 (iv) Flood: (Put Tick Mark) Increased / Decreased / Remained same / Does not know

Observed impacts of change in Flood (Put Tick Mark)

(a) Increased frequency in Flood

(b) Decreased frequency in Flood

(c) Increased intensity of Flood

(d) Decreased intensity of Flood

(e) Land erosion

(f) Damage of river embankment

(g) Damage of pond embankment

(h) Loss of Life

(i) Loss of crop

(j) Lossof property

(k) Others (if any, please mention)

19 (v) Ground Water Level: (Put Tick Mark)

Increased / Decreased / Remained same / Does not know

E. IMPACT OF CLIMATE CHANGE ON CULTURE FISHERY

20. Impacts of climate induced changes like temperature, rainfall, cyclone, flood etc. on aquacultures

(Tick the appropriate ones and put score against likelihood and consequence)

Likelihood score can be:

(1) Very unlikely, (2) Unlikely, (3) Fairly likely, (4) Likely, (5) Very likely

Consequence score can be:

(1) Insignificant, (2) Minor, (3) Moderate, (4) Major, (5) Catastrophic

S.N.	**Impacts on Aquaculture** (Tick appropriate ones)	**Likelihood** (Score)	**Consequence** (Score)
(i)	Breach of pond dyke		
(ii)	Ingression of flood water into pond		
(iii)	Escape of fish stock from pond		
(iv)	Mortality of fishes		
(v)	Entry of unwanted fishes		
(vi)	Growth retardation of fishes		
(vii)	Damage to pond environment		
(viii)	Deterioration of water quality		
(iX)	Rise in disease outbreak / parasitic infection		
(x)	Early drying of pond in summer		
(xi)	Changes in breeding periodicity of auto-recruiting fish species		
(xii)	Scarcity of water due to lower of ground water level (for bore-well dependent pond)		
(xiii)	Any other (explain, if any)		

F. COPING MEASURES ADOPTED BY FARMERS

21. Indicate the coping measures adopted by the farmers (Tick the appropriate ones)

(i) Increase of pond dyke height

(ii) Erecting net fencing around the pond

(iii) Harvesting the crop before flood

(iv) Plantations on pond dyke

(v) Pumping out the flood water

(vi) Pumping out of polluted water & addition of freshwater

(vii) Application of lime / disinfectants

(viii) No response measures taken

(ix) Lower of submersible pump / digging deeper bore-well

(x) Any other measure (describe, if any)

*** Thank You for kind cooperation ***

Signature of the Farmer

Signature of Surveyor

Date:

Signature of Reviewer

Date:

Annexure-II

Focus Group Discussions (FGD)

Culture Fishery

Questionnaire Template

Purpose

The purpose of the FGD is to conduct in-depth discussion and to collect perceptions, opinions, beliefs, and attitudes towards different fisheries activities as well as their viewpoints on gender issues, impact of climate change, climate resilient aquatic food production system, etc.

Guidelines

- The Ground rule is that everybody should feel free to speak. But, one person should talk at a time. If several people talk at the same time, it will be difficult to capture their views and comments clearly.
- Questions will be adapted to the context cited under the purpose.
- It should help to cross-check the information given in individual interviews and by field visits.
- The group will be as representative of the local community as possible (men and women, people of different age, wealth and activity groups-culture and capture fisheries)
- The group will not be too large (maximum up to 20 persons) for effective discussion and meaningful inferences.
- The explanation will be put forth before the participants on the purpose of the interview and how the gathered information will be used by WorldFish.

1. Date of FGD	
2. Name of village / FGD location	
3. Number of people attending the FGD	Men _____ Women _____ Total _____
4. Composition of Participants	☐ Fish Farmers ☐ Fishermen

(Tick appropriate ones)	☐ Common Interest Group (CIG) ☐ FPO members ☐ Community representatives/ leaders ☐ Traders

5. Perceptions on Climate Change and related hazards

5 (i). How do you perceive the climate change over the last 30 years? (Tick options)

Parameters	Increased	Decreased	Extreme change	Unseasonal	No change
Temperature					
Rainfall pattern					
Intensity of Cyclone					
Frequency of cyclone					
Prolonged Drought					
Short-term Drought					
Ground water Level					

5 (ii). What kind of natural hazards/disasters do you experience? (Tick options)

Hazards/ Disaster	Yearly	2-5 years interval	5-10 years interval	10-20 years interval	20-50 years interval
Flooding					
Cyclone					
Riverbank erosion					
Inundation of agril. land, fishpond, etc.					

5 (iii). How were you affected by natural disasters during last 10-30 years?

Disasters	Year of disaster	Affected resources	Loss (in Rs.)	Amount of relief		
				Govt.	NGOs	Others
Flooding						
Cyclone						
Riverbank erosion						
Inundation of agril. land, fishpond, etc.						
Unaffected						

5 (iv). a) Does flood water or storm inundate your house? Yes / No
b) If house inundated, mention number of days of inundation: ( )
c) Does flood water or storm inundate your fishpond? Yes

d) If fishpond inundated, mention number of days of inundation: ( )

e) Indicate the hazard recovery time: ( )

f) What are the causes of inundation? i) .....

ii) .....

iii) .....

5 (v). a) Who are most vulnerable members of your family in climatic hazards?

b) Have you ever relocated in disaster shelter during flood/cyclone?

c) Where do you take shelter during disaster (s)?

d) How much distance of the disaster shelter from your house?

e) Do you face any problem in the disaster shelter? Yes / No

f) How do you get warning of disasters?

5 (vi). a) Which is the most important climate event affecting the culture fishery?

b) What is the impact of climate change on fish yields in culture fishery?

c) What is the impact of climate change on incidence of parasite & diseases in fish?

d) What is the impact of climate change on ground water table?

6. Impact of Climate induced hazards on Aquatic food Production System

6. Please indicate the impact of climate induced hazards like flood, drought, etc. on aquatic food production system (pond aquaculture)

S.N.	**Impacts on Culture Fishery** (Tick the appropriate ones)	**Please discuss on Likelihood and Consequence in detail**
(i)	Breach of dyke / embankment	
(ii)	Ingression of flood water into pond	
(iii)	Escape of fish stock from pond	
(iv)	Mortality of fishes	
(v)	Mortality of seed during transportation due to rise in tem.	
(vi)	Delayed Stocking	
(vii)	Entry of predatory fishes	
(viii)	Growth retardation of fishes	
(ix)	Growth enhancement of fish	
(x)	Damage to ecosystem	
(xi)	Deterioration of water quality	

(xii)	Rise in disease outbreak	
(xiii)	Early drying of pond (for rain-fed pond)	
(xiv)	Scarcity of water due to lower of ground water level (for bore-well dependent pond)	
(xv)	Changes in availability of self-recruiting species / SIS like Mola etc.	
(xvi)	Changes of breeding periodicity of SIS	
(xvii)	Any other (explain, if any)	

7. Coping / Adaptation Measures

7 (i). Indicate and discuss on the coping measures adopted to counter the Impact of Climate Change on pond aquaculture

- .
- .
- .
- .
- .
- .
- .
- .

7 (ii). What have you done to secure your livelihoods (e.g. production/business) from climate induced hazards?

- Modification in fish farming
- Change in crop
- Change in planting date
- Change in dwelling place
- Modification of infrastructure
- Nothing

7 (iii). In your opinion, who should take responsibility for responding to climate impacts? (Tick the appropriate one)

Community / Local government / State Govt. / Central Govt. / NGO / Does not know

7 (iv). In your opinion, what actions should government take in response to climate impacts?

- .
- .
- .
- .
- .

8. Use of Weather Information

8 (i). Do you use any weather information? If yes, tell the type of information you use.

- ☐ Daily weather forecast
- ☐ Weekly weather forecast
- ☐ Forecast on rainfall only
- ☐ Seasonal weather forecast

8 (ii). What are the sources of your weather information?

- ☐ Radio
- ☐ Newspaper
- ☐ Television
- ☐ Neighbours
- ☐ Other (Specify)
- ☐

8 (iii). For what purpose do you use weather information?

- ☐ For pond preparation
- ☐ For Liming
- ☐ For taking precautionary measure
- ☐ For seed stocking
- ☐ For Harvesting
- ☐ Other (Specify)

8 (iv). If you don't use any weather information, what is the reason?

- ☐ I don't need it
- ☐ I don't know how to use it
- ☐ I don't have any means
- ☐ I don't know where to get it
- ☐ I don't have access to it
- ☐ Weather information is not reliable

9. Gender Issues

9 (i). Gender involvement in decision making and implementation

Please indicate the Gender & Age Group
- Gender (Man / Women / Both);
- Age Group (Child / Young / Adult / Elder/ All age group)

Issues	Who initiates	Who participates	Who decides	Who implements
Fish Species for culture				
Purchase of inputs like seed, feed etc.				
Culture Activities (stocking, liming, feeding, harvesting, etc.)				
Coping measures adopted to counter the Impact of Climate Change				
Domestic activities				
Money management				
Child education				
Social Commitment				

9 (ii). Gender relations in Access and Control over resources and benefits

Please indicate whether men, women or both have access to resources, who control their use and who control the benefits deriving from the use of resources (tick the appropriate one)

	Access	Control

Resources & Benefits	Man	Woman	Both	Man	Woman	Both
Land						
Equipment						
Cash						
Basic needs (food, clothing, shelter, etc.)						
Primary Education						
Secondary Education						
Higher Education						
Others (please specify)						

9 (iii). Gender Dimensions of Climate Change Vulnerability

Please indicate women's vulnerability compared to men's (tick the appropriate one)

Attributes	Lower (worse)	Equal	Higher (better)
Decreased Nutritional security			
Loss of livelihoods			
Water resources - shortage and access			
Hardship after high-intensity weather event like cyclone, flood, etc.			

10. Nutrition sensitivity of Pond fishery & its vulnerability to climate change

10 (i) In general, small fish species contain more micronutrients than large fish from aquaculture.

a. Due you culture small indigenous species (sis) along with main species -

yes / No

b. If yes, name the small indigenous species you culture -

c. Comment on availability small indigenous species for home consumption -

10 (ii) The period from the start of a woman's pregnancy to her child's second birthday (total 1000 days) offers a unique window of opportunity to shape healthier and more prosperous futures and help break the cycle of poverty.

a. Availability of fish for women as compared to men in the family –

same / more / less

b. Comment on availability of fish to pregnant and lactating women -

10 (iii) Integrated Fish-vegetable farming is a nutrition-sensitive practice. Growing micronutrient-rich seasonal vegetable in the dyke of pond is one of them.

a. Do you grow seasonal vegetables in the dyke of the pond? Yes / No

b. If yes, do you use them for home consumption? Yes / No

c. What is the impact of flood and drought on the production of vegetable grown on the dyke of the pond?

11. Indigenous Technical Knowledge (ITK) used in Fisheries

ITK Recorded	ME	E	LE	IE	CS	Scientific Rationale

(Tick the appropriate one - **ME:** Most Effective, **E:** Effective, **LE:** Less Effective, **IE:** Ineffective, **CS:** Can't say)

Annexure-III

Focus Group Discussions (FGD)

Capture Fishery

Questionnaire Template

Purpose

The purpose of the FGD is to conduct in-depth discussion and to collect perceptions, opinions, beliefs, and attitudes towards different fisheries activities as well as their viewpoints on gender issues, impact of climate change, climate resilient aquatic food production system, etc.

Guidelines

- The Ground rule is that everybody should feel free to speak. But, one person should talk at a time. If several people talk at the same time, it will be difficult to capture their views and comments clearly.
- Questions will be adapted to the context cited under the purpose.
- It should help to cross-check the information given in individual interviews and by field visits.
- The group will be as representative of the local community as possible (men and women, people of different age, wealth and activity groups-culture and capture fisheries)
- The group will not be too large (maximum up to 20 persons) for effective discussion and meaningful inferences.
- The explanation will be put forth before the participants on the purpose of the interview and how the gathered information will be used by WorldFish.

5. Date of FGD	**2. Place of FGD**	**3. Name of the *Beel* & Area**

4. No. of villages around *Beel*	**5. No. of households dependent on beel**

6. Number of people attending the FGD	Men _____ Women _____ Total _____

7. Composition of Participants (Tick appropriate ones)	☐ Fish Farmers ☐ Fishermen ☐ Common Interest Group (CIG) ☐ FPO members ☐ Community representatives/ leaders ☐ Traders

8. Perceptions on Climate Change and related hazards

8 (i). How do you perceive the climate change over the last 30 years? (Tick options)

Ground water Level	Ground water Level	Ground water Level	Ground water Level	Ground water Level	Ground water Level
Temperature					
Rainfall pattern					
Intensity of Cyclone					
Frequency of cyclone					
Prolonged Drought					
Short-term Drought					
Ground water Level					

8 (ii). What kind of natural hazards/disasters do you experience? (Tick options)

Hazards/ Disaster	**Yearly**	**2-5 years interval**	**5-10 years interval**	**10-20 years interval**	**20-50 years interval**
Flooding					
Cyclone					
Riverbank erosion					
Inundation of agril. land, *Beel*, etc.					

8 (iii). How were you affected by natural disasters during last 10-30 years?

Disasters	**Year of disaster**	**Affected resources**	**Loss (in Rs.)**	**Amount of relief**		
				Govt.	**NGOs**	**Others**
Flooding						
Cyclone						
Riverbank erosion						
Inundation of agril. land, fishpond, etc.						
Unaffected						

8 (iv). a) Does flood water or storm inundate your house? Yes / No

b) If house inundated, mention number of days of inundation: ( )
c) Does flood water or storm inundate the *Beel*? Yes / No
d) If yes, mention number of days of inundation: ( )
e) Indicate the hazard recovery time (in days): ( )
f) What are the causes of inundation? i) .....
ii) .....
iii) .....

8 (v). a) Who are most vulnerable members of your family in climatic hazards?

b) Have you ever relocated in disaster shelter during flood/cyclone?

c) Where do you take shelter during disaster (s)?

d) How much distance of the disaster shelter from your house?

e) Do you face any problem in the disaster shelter? Yes / No

f) How do you get warning of disasters?

8 (vi). a) Which is the most important climate event affecting the *beel* fishery?

b) What is the impact of climate change on fish yields in *beel* fishery?

e) What is the impact of climate change on incidence of parasite & diseases in fish?

f) What is the impact of climate change on ground water table?

9. Impact of Climate induced hazards on Aquatic food Production System

9. Please indicate the impact of climate induced hazards like flood, drought, etc. on aquatic food production system (*Beel*/wetland fishery)

S.N.	**Impacts on Culture Fishery** (Tick the appropriate ones)	**Please discuss on Likelihood and Consequence in detail**
(i)	Breach of dyke / embankment	
(ii)	Ingression of flood water into *Beel* / wetland	
(iii)	Escape of fish stock from *Beel*/ wetland	
(iv)	Mortality of fishes	
(v)	Mortality of seed during transportation due to rise in tem.	
(vi)	Delayed Stocking	
(vii)	Entry of predatory fishes	
(viii)	Growth retardation of fishes	
(ix)	Growth enhancement of fish	

(x)	Damage to ecosystem	
(xi)	Deterioration of water quality	
(xii)	Rise in disease outbreak	
(xiii)	Early drying of *Beel* / wetland in summer	
(xiv)	Changes in availability of self-recruiting species / SIS like Mola etc.	
(xv)	Changes of breeding periodicity of SIS	
(xvi)	Any other (explain, if any)	

10. Coping / Adaptation Measures

10 (i). Indicate and discuss on the coping measures adopted to counter the Impact of Climate Change on *Beel* fishery

- .
- .
- .
- .
- .
- .
- .
- .

10 (ii). What have you done to secure your livelihoods (*e.g.,* production/business) from climate induced hazards?

- ☐ Modification in *beel* management
- ☐ Change in harvesting pattern
- ☐ Change in dwelling place
- ☐ Modification of infrastructure
- ☐ Others (specify)
- ☐ Nothing

10 (iii). In your opinion, who should take responsibility for responding to climate impacts? (Tick the appropriate one)

Community / Local government / State Govt. / Central Govt. / NGO / Does not know

10 (iv). In your opinion, what actions should government take in response to climate impacts?

- .
- .
- .
- .

11. Use of Weather Information

11 (i). Do you use any weather information? If yes, tell the type of information you use.

- ☐ Daily weather forecast
- ☐ Weekly weather forecast
- ☐ Forecast on rainfall only
- ☐ Seasonal weather forecast

11 (ii). What are the sources of your weather information?

- ☐ Radio
- ☐ Television
- ☐ Other (Specify)
- ☐ Newspaper
- ☐ Neighbours

11 (iii). For what purpose do you use weather information?

- ☐ For pond preparation
- ☐ For seed stocking
- ☐ For Liming
- ☐ For Harvesting
- ☐ For taking precautionary measure
- ☐ Other (Specify)

11 (iv). If you don't use any weather information, what is the reason?

- ☐ I don't need it
- ☐ I don't know where to get it
- ☐ I don't know how to use it
- ☐ I don't have access to it
- ☐ I don't have any means
- ☐ Weather information is not reliable

12. Gender Issues

12 (i). Gender involvement in decision making and implementation

Please indicate the Gender & Age Group

- Gender (Man / Women / Both);
- Age Group (Child / Young / Adult / Elder/ All age group)

Issues	Who initiates	Who participates	Who decides	Who implements
Fish Species for culture				
Purchase of inputs like seed				

Culture Activities (stocking, liming, feeding, harvesting, etc.)				
Coping measures adopted to counter the Impact of Climate Change				
Domestic activities				
Money management				
Child education				
Social Commitment				

12 (ii). Gender relations in Access and Control over resources and benefits

Please indicate whether men, women or both have access to resources, who control their use and who control the benefits deriving from the use of resources (tick the appropriate one)

	Access			Control		
Resources & Benefits	**Man**	**Woman**	**Both**	**Man**	**Woman**	**Both**
Land						
Equipment						
Cash						
Basic needs (food, clothing, shelter, etc.)						
Primary Education						
Secondary Education						
Higher Education						
Others (please specify)						

12 (iii). Gender Dimensions of Climate Change Vulnerability

Please indicate women's vulnerability compared to men's (tick the appropriate one)

Attributes	**Lower (worse)**	**Equal**	**Higher (better)**
Decreased Nutritional security			
Loss of livelihoods			
Water resources - shortage and access			
Hardship after high-intensity weather event like cyclone, flood, etc.			

13. Nutrition sensitivity of *Beel* fishery & its vulnerability to climate change

13 (i) In general, small fish species from capture (*beel*) fisheries contain more micronutrients than large fish from aquaculture.

a. Availability of fish over the years from *beel* for home consumption –

Increased / Decreased / unchanged

b. Comment on availability of fish for home consumption during flood-

c. Comment on availability fish for home consumption during drought / water stress situation -

13 (ii) The period from the start of a woman's pregnancy to her child's second birthday (total 1000 days) offers a unique window of opportunity to shape healthier and more prosperous futures and help break the cycle of poverty.

a. Availability of fish for women as compared to men in the family –

same / more / less

b. Comment on availability of fish to pregnant and lactating women -

13 (iii) Integrated Fish-vegetable farming is a nutrition-sensitive practice. Growing micronutrient-rich seasonal vegetable in the periphery of *beel* is one of them.

a. Do you grow seasonal vegetables in the periphery of *beel*? Yes / No

b. If yes, do you use them for home consumption? Yes / No

c. What is the impact of flood and drought on the production of vegetable grown in the periphery of *beel* ?

14. Indigenous Technical Knowledge (ITK) used in Fisheries

ITK Recorded	ME	E	LE	IE	CS	Scientific Rationale

(Tick the appropriate one - **ME:** Most Effective, **E:** Effective, **LE:** Less Effective, **IE:** Ineffective, **CS:** Can't say)

Annexure-IV

Focus Group Discussions (FGD)

Seed Production

Questionnaire Template

Purpose

The purpose of the FGD is to conduct in-depth discussion and to collect perceptions, opinions, beliefs, and attitudes towards different fisheries activities as well as their viewpoints on gender issues, impact of climate change, climate resilient aquatic food production system, etc.

Guidelines

- The Ground rule is that everybody should feel free to speak. But, one person should talk at a time. If several people talk at the same time, it will be difficult to capture their views and comments clearly.
- Questions will be adapted to the context cited under the purpose.
- It should help to cross-check the information given in individual interviews and by field visits.
- The group will be as representative of the local community as possible (men and women, people of different age, wealth and activity groups-culture and capture fisheries)
- The group will not be too large (maximum up to 20 persons) for effective discussion and meaningful inferences.
- The explanation will be put forth before the participants on the purpose of the interview and how the gathered information will be used by WorldFish.

6. Date of FGD	
2. Place of FGD	
3. Number of people attending the FGD	Men _____ Women _____ Total _____

4. Composition of Participants **(Tick appropriate ones)**	☐ Hatchery Owners ☐ Seed Growers ☐ Fish Farmers ☐ FPO members ☐ Common Interest Group (CIG) ☐ Traders

5. General Information about Hatchery Operation

Type of seed production system:	
Major species bred:	
Seed production capacity per year:	
Age of brood stock and average body weight	
Source of brood stock	
Sex ratio of the brood stock	
Management practice of brood stock pond	
Induced spawning method	

6. Perceptions on Climate Change and related hazards

6 (i). How do you perceive the climate change over the last 30 years? (Tick options)

Parameters	**Increased**	**Decreased**	**Extreme change**	**Unseasonal**	**No change**
Temperature					
Rainfall pattern					
Intensity of Cyclone					
Frequency of cyclone					
Prolonged Drought					
Short-term Drought					
Ground water Level					

6 (ii). What kind of natural hazards/disasters do you experience? (Tick options)

Hazards/ Disaster	**Yearly**	**2-5 years interval**	**5-10 years interval**	**10-20 years interval**	**20-50 years interval**
Flooding					
Cyclone					

Riverbank erosion					
Inundation of agril. land, fishpond, etc.					

6 (iii). How were you affected by natural disasters during last 10-30 years?

Disasters	Year of disaster	Affected resources	Loss (in Rs.)	Amount of relief		
				Govt.	NGOs	Others
Flooding						
Cyclone						
Riverbank erosion						
Inundation of Hatchery, fishpond, etc.						
Unaffected						

6 (iv). a) Does flood water or storm inundate your hatchery? Yes / No

d) If yes, mention number of days of inundation: ( )

e) Indicate the hazard recovery time: ( )

f) What are the causes of inundation? i) .....

ii) .....

iii) .....

6 (vi). a) Which is the most important climate event affecting the hatchery operation?

c) What is the impact of climate change on fish seed production?

d)What is the impact of climate change on incidence of spawning of fish?

f) What is the impact of climate change on ground water table?

7. Impact of climate variation on Fish Breeding & Seed Rearing

7. Seasonal calendar of hatchery related activities and the climate-induced changes over time

S.N.	Impacts on **reproductive efficacy** (Tick the appropriate ones)	Please discuss in detail
(i)	Fecundity (+/-)	
(ii)	Maturation of gonad (Advanced / Delayed)	
(iii)	Number of spawning in a year (+/-)	
(iv)	Shifting breeding days	
(v)	Susceptibility of brood fish to diseases	
(vi)	Mortality of seed during transportation due to rise in temp.	

(vii)	Relationship between spawn quality and temperature increase and rainfall	
(viii)	Relationship between spawning characteristics and climatic variables	
(ix)	Scarcity of water due to lower of ground water level (for bore-well dependent hatcheries)	
(x)	Any other problem in hatchery operation	
(xi)	Any other problem in seed rearing	

8. Coping / Adaptation Measures

8 . Indicate and discuss on the coping measures adopted to counter the Impact of Climate Change on fish breeding, hatchery operations and seed rearing

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9. Use of Weather Information

9 (i). Do you use any weather information? If yes, tell the type of information you use.

- ☐ Daily weather forecast
- ☐ Weekly weather forecast
- ☐ Forecast on rainfall only
- ☐ Seasonal weather forecast

9 (ii). What are the sources of your weather information?

- ☐ Radio
- ☐ Newspaper
- ☐ Other (Specify)
- ☐ Television
- ☐ Neighbours

9 (iii). For what purpose do you use weather information?

- ☐ For Breeding
- ☐ For hatchery operation
- ☐ For lifting water to overhead tank
- ☐ For netting the Brood Fish
- ☐ For taking precautionary measure
- ☐ Other (Specify)

9 (iv). If you don't use any weather information, what is the reason?

- ☐ I don't need it
- ☐ I don't know where to get it
- ☐ I don't know how to use it
- ☐ I don't have access to it
- ☐ I don't have any means
- ☐ Weather information is not reliable

10. Indigenous Technical Knowledge (ITK) used in Fish Breeding and seed rearing

ITK Recorded	ME	E	LE	IE	CS	Scientific Rationale

(Tick the appropriate one - **ME:** Most Effective, **E:** Effective, **LE:** Less Effective, **IE:** Ineffective, **CS:** Can't say)

Annexure-V

Key Informant Interview (KII)

Questionnaire

Background Information

Culture and capture fisheries provide livelihoods for thousands of rural households in Assam, who are directly or indirectly involved in the production fish and its value chain. The present production from culture and capture fisheries is far below the potential productivity as well as below the productivity achieved by some other states. Foreseeing the high potential in the sector, Govt. of Assam has launched the project "Assam Agribusiness and Rural Transformation Project (APART)" with financial assistance from World Bank in targeted districts of Assam. Fish is prioritized as one of the value chains for interventions in APART. WorldFish is providing technical support to the fishery components of the project. Application of climate resilient technologies for productivity enhancement in culture and capture fisheries is one of the project intervention areas. The current questionnaire based survey is a part of the Government sponsored study aimed at formulating climate resilient strategies in aquaculture and fisheries for Assam. Key Informant Interview (KII) is an in-depth interview with the people who are well conversant with the concerned topic or issue and are capable of offering suggestions and advices.The information gathered will not be shared with anybody, except for in-house analysis to draw inferences. Therefore, please feel free to share your frank views and opinions.

A. GENERAL INFORMATION	
1. NAME OF THE RESPONDENT :	
2. DESIGNATION & ORGANISATION:	**Mobile No.** **E mail:**
B. PERCEPTIONS ON CLIMATE CHANGE	
3. Do you perceive the change of climate? (Put Tick Mark): Yes / No	

4. If yes, please share your experience of changes: (Put Tick Mark)

4 (i) Temperature: Increased / Decreased / Remained same / Does not know

Observed impacts of change in Temperature (Put Tick Mark)

(a) Hotter Summer
(b) Long Summer
(c) Short winter
(d) irregularities in season change
(e) Drought
(f) Others (if any, please mention)

4 (ii) Rainfall: (Put Tick Mark) Increased / Decreased / Remained same / Does not know

Observed impacts of change in Rainfall (Put Tick Mark)

(a) Erratic Monsoon
(b) Shortening of Monsoon Season
(c) Lingering of Monsoon Season
(b) Low Rainfall
(c) High Rainfall
(d) Heavy rainfall during onset and offset of monsoon
(f) Others (if any, please mention)

4 (iii) Cyclone: (Put Tick Mark) Increased / Decreased / Remained same / Does not know

Observed impacts of change in Cyclone (Put tick mark in appropriate ones)

a) Increased frequency in cyclones
b) Decreased frequency in cyclones
c) Increased intensity of cyclones
d) Decreased intensity of cyclones
e) Heavy downpour during cyclone
f) Loss of Life
g) Loss of crop
h) Loss of property
i) Others (if any, please mention)

4 (iv) Flood: (Put Tick Mark) Increased / Decreased / Remained same / Does not know

Observed impacts of change in Flood (Put tick mark in appropriate ones)

(a) Increased frequency in Flood
(b) Decreased frequency in Flood
(c) Increased intensity of Flood
(d) Decreased intensity of Flood
(e) Land erosion
(f) Damage of river embankment
(g) Damage of dyke of water bodies
(h) Loss of Life

(i) Loss of crop (j) Loss of property

(k) Others (if any, please mention)

4 (v) Ground Water level : (Put Tick Mark)

Increased / Decreased / Remained same / Does not know

5. Please indicate your level of agreement or disagreement to the following statements. (Please tick in appropriate columns)

Statements	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
a) The general understanding of the implications of climate change is improving. However, information on local-level impacts and vulnerabilities is lacking, which hampers adaptation planning.					
b) Climate smart adaptation needs to take place at all levels (individual, business, community, national and regional) and time scales. All stakeholders from private and public sectors should be involved in developing context-specific options.					
c) Considering the uncertainties of the climate change, it is necessary to have climate resilient strategies that both support general development and climate adaptation in the vulnerable region.					
d) Climate change crisis may bring some new opportunities in fisheries sector. This will create climate-smart business opportunities for development in the sector.					
e) The climate change impacts in aquatic food production system affect the nutrition security, consumer prices and supply-demand gaps. Therefore, the implications of climate change on the entire supply and value chain need to be better understood.					

C. IMPACT OF CLIMATE CHANGE ON SEED PRODUCTION, CULTURE & CAPTURE FISHERY

6. Impacts of climate induced changes like temperature, rainfall, cyclone, flood etc. on culture fishery

(Tick the appropriate ones and put score against likelihood and consequence)

Likelihood score can be:
(1) Very unlikely, (2) Unlikely, (3) Fairly likely, (4) Likely, (5) Very likely

Consequence score can be:
(1) Insignificant, (2) Minor, (3) Moderate, (4) Major, (5) Catastrophic

S.N.	**Impacts on Aquaculture** (Tick appropriate ones)	**Likelihood** (Score)	**Consequence** (Score)
(i)	Breach of dyke		
(ii)	Ingression of flood water into pond/wetland		
(iii)	Escape of fish stock from water body		
(iv)	Mortality of fishes		
(v)	Entry of unwanted fishes		
(vi)	Growth retardation of fishes		
(vii)	Damage to water body environment		
(viii)	Deterioration of water quality		
(iX)	Rise in disease outbreak		
(x)	Early drying of water body in summer		
(xi)	Any other (explain, if any)		

D. COPING MEASURES FOR SEED PRODUCTION, CULTURE & CAPTURE FISHERY

7. Indicate the short-term coping measures adopted by the farmers/fishermen/ Hatchery operator (Please list out)

- .

- .
- .
- .
- .
- .

E. ADAPTATION STRATEGY FOR CULTURE & CAPTURE FISHERY

8. Indicate the long-term climate-smart adaptation strategy for fisheries, aquaculture and seed production. (Please list out)

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- .
- .
- .
- .

9. What are the gaps you identify in the adoption of climate resilient technologies in fisheries, aquaculture and seed production? Please mention.

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F. CLIMATE CHANGE IMPACT ON FISH VALUE CHAIN

10. Fish value chain is the entire series of activities starting from the production system till it reaches the consumer. The principal actors of fish value chain are hatchery owners, seed growers, farmers, feed manufacturers and input suppliers, service providers, traders (wholesalers & Retailers), processors and consumers. The climate change may have negative as well positive impacts directly or indirectly on above actors. Please list out them.

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11. How to establish Intellectual Property Rights (IPR) for ITKs related to climate-resilient practices? Please offer some suggestions.

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G. CLIMATE SMART INVESTMENT OPPORTUNITY IN FISHERIES

11. What could be the climate smart interventions for small-scale aquaculture? (Tick the appropriate ones.

- ☐ Adoption of BMP
- ☐ Stocking of advanced fingerling
- ☐ Effective dyke management and intercropping in dyke
- ☐ Adoption of biosecurity
- ☐ Application of low-cost organic manure
- ☐ Periphyton based food production
- ☐ Deep-water Rice-fish integration
- ☐ Short-term fish grow-out
- ☐ Overwintering of fish seed
- ☐ Stocking of self-recruiting species / SIS like Mola etc.
- ☐ Sack cultivation of vegetable on pond dyke
- ☐ Floating cultivation of vegetable in wetland
- ☐ Any other points in your mind

12. The fisheries and aquaculture sector is likely to have impacts on productivity and livelihoods as a result of climate change and climate variability. The impacts of climate change and adaptation options vary by region. In the context of Assam, climate-smart investment opportunities in fisheries (both culture and capture) will be the key for future development. Investment will be required in different areas like seed production, aquaculture, health management, fishery development in wetland, development of fishery related infrastructure and facilities, etc. Please list out them.

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13. Which sub-sectors / activities of aquaculture and fisheries are responsible for carbon emission and how can be reduced? Please offer some suggestions.

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14. As a part of state level adaptation plan, can you please suggest some schemes for the Govt. to implement?

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Annexure-VI

List of Farmers covered in Knowledge-Attitude-Practice (KAP) Survey

S.N.	Name of the Farmer	Address	Sex	Age	Caste
District: Barpeta					
1	Amarendra Baishya	Dabalipara, Bhawanipur	Male	48	Gen
2	Dhiruwar Barman	Byaskuchi, Sarukhetri	Male	47	Gen
3	Dalandra Seal	Dabalipara, Bhawanipur	Male	49	Gen
4	Binod Barman	Byaskuchi, Sarukhetri	Male	45	Gen
5	Dinesh Deka	Byaskuchi, Sarukhetri	Male	40	Gen
6	Gopeswar Baishya	Byaskuchi, Sarukhetri	Male	46	Gen
7	Sankar Baishya	Byaskuchi, Sarukhetri	Male	50	Gen
8	Ranjit Baishya	Dabalipara, Bhawanipur	Male	40	Gen
9	Satyendra Barma	Byaskuchi, Sarukhetri	Male	51	Gen
10	Peatul Choudhury	Dabalipara, Bhawanipur	Male	46	Gen
District: Cachar					
11	Ananta Bala Das	Shyampur, Silehar	Female	42	SC
12	Joydeep Das	Dwarband Basti, Silehar	Male	41	SC
13	Chandan Yadav	Barik Nagar, Silehar	Male	38	OBC
14	Budhai Das	Shyampur, Silehar	Male	39	Gen
15	Jyatirmoay Das	Labourbond, Udharbond	Male	40	SC
16	Naresh Das	Labourbond, Udharbond	Male	40	SC
17	Rajen Rai	Ratanpur Colony, Silehar	Male	42	SC
18	Sankar Bhattacharya	Chotojalengapt 3, Silehar	Male	40	Gen
19	Sugandha Kairi	Borjalenga Boya, Silehar	Female	39	OBC
20	Sandipan Malakar	Labourbond, Udharbond	Male	38	SC
District: Darrang					
21	Aluk Nath	Akalibari, Kalaigaon	Male	45	OBC
22	Bhadra Kanta Bora	Bengabora	Male	43	OBC
23	Jatin Chandra Deka	Kaith Para, Kalaigaon	Male	42	OBC
24	Nayan Saharia	Bechimari outala, Bechimari	Male	39	OBC
25	Khirod Deka	Bechimari outala, Bechimari	Male	45	OBC
26	Padumi Deka	Balipata, Kalaigaon	Male	39	OBC
27	Rabidhar Rabha	Lakhimpur, Kalaigaon	Male	45	OBC
28	Ramesh Deka	Lakhimpur, Kalaigaon	Male	40	OBC
29	Ranu Deka	Balipata, Kalaigaon	Female	40	OBC

30	Someswar Baruah	Kaith Para, Kalaigaon	Male	40	OBC
District: Jorhat					
31	Bhadreswar Gogoi	Mallacokhat, New Jorhat	Male	48	OBC
32	Arun Darabdhara	Mallacokhat, New Jorhat	Male	39	OBC
33	Jibon Gogoi	Mallacokhat, New Jorhat	Male	47	OBC
34	Anandi Bordoloi	Mallacokhat, New Jorhat	Male	42	Gen
35	Anup Chetia	Mallacokhat, New Jorhat	Male	37	Gen
36	Kon Bora	Mallacokhat, New Jorhat	Male	38	OBC
37	Mohan Gogoi	Mallacokhat, New Jorhat	Male	45	OBC
38	Nil Chetri	Mallacokhat, New Jorhat	Male	40	OBC
39	Rajib Chetri	Mallacokhat, New Jorhat	Male	35	OBC
40	Nabajyoti Bora	Mallacokhat, New Jorhat	Male	40	OBC
District: Nagaon					
41	Shahidul Khan	Saidoria, Rupahi	Male	35	Muslim
42	Iman Ali Ahmed	Singimari, Rupahi	Male	40	Muslim
43	Abdul Kalam Azad	Saidoria, Rupahi	Male	49	Muslim
44	Jakirul Islam	Singimari, Rupahi	Male	40	Muslim
45	Dinesh Goswami	Singimari, Rupahi	Male	43	Gen
46	Lakhsman Swargiary	Saidoria, Rupahi	Male	51	Gen
47	Lokman Ali	Saidoria, Rupahi	Male	45	Muslim
48	Mukul Goswami	Saidoria, Rupahi	Male	42	Gen
49	Niranjan Medhi	Saidoria, Rupahi	Male	38	OBC
50	Muzammel Hussain	Saidoria, Rupahi	Male	52	Muslim
District: Nalbari					
51	Amal Medhi	Sandha, Pub Nalbari	Male	35	Gen
52	Akram Hussain	Milanpur, Nalbari	Male	46	Muslim
53	Brajen Mahender	Sandha, Pub Nalbari	Male	34	Gen
54	Brajen Rajbongshi	Sandha, Pub Nalbari	Male	24	Gen
55	Dipen Kalita	Sandha, Pub Nalbari	Male	33	Gen
56	Hareshwar Baishya	Milanpur, Nalbari	Male	43	Gen
57	Ramesh Baishya	Sandha, Pub Nalbari	Male	35	Gen
58	Hased Ali	Sandha, Pub Nalbari	Male	45	Muslim
59	Ratul Kalita	Milanpur, Nalbari	Male	35	Gen
60	Ramani Kalita	Milanpur, Nalbari	Male	33	Gen

Annexure-VII

List of Experts included in Key Informant Interview (KII)

S.N.	Name of the Respondent	Designation & Organisation	Mobile No.	E mail
1	Prof. Binod Kalita	Dean, College of Fisheries, Raha, AAU	9864244477	binod_kalita@gmail.com
2	Dr. B. K. Bhattachariya	Pr. Scientist & OIC, ICAR-CIFRI, RC Guwahati	9435553274	bkbhattachariya@gmail.com
3	Dr. Sanjay Sarma	ARIAS Society, Govt of Assam	9435309568	sanjaysarma@arias.in
4	Mr. Sangipran Baishya	Asst. Professor, College of Fisheries, Raha, AAU	9678525579	sangipran@gmail.com
5	Mr. Simanku Borah	Scientist, ICAR-CIFRI, RC Guwahati	8638575168	simankuborah@gmail.com
6	Dr. Sona Yengkokpam	Sr. Scientist, ICAR-CIFRI, RC Guwahati	8486542819	sonayen@gmail.com
7	Dr. Utpal Kumar Das	Asst. Professor, College of Fisheries, Raha, AAU	7638830484	dasutpal101@gmail.com
8	Mr. Kaustubh Bhagawati	Asst. Professor, College of Fisheries, Raha, AAU	8133847352	kaustubhbhagawati@gmail.com
9	Dr. Ningthoujam S. Singh	Scientist, ICAR-CIFRI, RC Guwahati	8638058098	tairenki@gmail.com
10	Prof. Sarifuddin Ahmed	Professor, College of Fisheries, Raha, AAU	9435364049	sarif17m@rediffmail.com
11	Dr. Niti Sharma	Scientist, ICAR-CIFRI, RC, Guwahati	8652898227	sharmaniti352@gmail.com
12	Dr. Pronob Das	Scientist, ICAR-CIFRI, RC, Guwahati	8473001970	pranabjaan80@gmail.com
13	Dr. Anil Kumar Yadav	Scientist, ICAR-CIFRI, RC, Guwahati	9508630380	yadav.anil.stats@gmail.com
14	Prof. D. K. Sarma	Professor, College of Fisheries, Raha, AAU	9435222725	dipak_sarma@yahoo.com
15	Dr. Dipesh Debnath	Scientist, ICAR-CIFRI, RC, Guahati	9101428563	dipesh_debnath@gmail.com
16	Ms. M S Dorothy	EA (Tech), NFDB, NERC, Govt. of India	7738673398	dorothy.nfdb@gmail.com
17	Mr. Ashim Kumar Borah	Executive (Tech), NFDB -NERC, Govt. of India	8638664691	akborah1980@gmail.com

18	Mr. Atanu Chatterjee	Environment Management Specialist (EMS), ARIAS society	9811090396	atanuchatterjee@arias.in
19	Dr. Bipul Kumar Kakati	Asst. Professor, College of Fisheries, Raha, AAU	8811804914	bkkakati@gmail.com
20	Dr. Shyanal C. S. Das	Scientist, ICAR-CIFRI, RC Guwahati	8756056892	scsdtin@gmail.com

Annexure-VIII

Details of Focus Group Discussions (FGD) & Participatory Rural Appraisal (PRA)

S.N.	Date of FGD	Venue	No. of Participants			FDG Theme
			M	F	T	
FDG						
1	11.02.2021	Digholi Beel, Dist: Kamrup (R)	11	7	18	*Beel* Fisheries
2	03.03.2021	Barfaladi Beel, Byaskuchi, Dist: Barpeta	10	0	10	*Beel* Fisheries
3	21.02.2021	Vill: Golibandha, Dist: Barpeta	9	3	12	Pond Aquaculture
4	21.02.2021	Vill: Pub Barala, Dist: Barpeta	9	0	9	Pond Aquaculture
5	22.02.2021	48 No. Thekera Beel, Dist: Morigaon	14	1	15	*Beel* Fisheries
6	22.02.2021	Vill: Kanchanpur, Dist: Nagaon	21	1	22	Pond Aquaculture
7	22.02.2021	Vill: Gereki, Ropahi, Dist: Nagaon	10	3	13	Pond Aquaculture
8	20.02.2021	Vill: Khudrakatla, Barkuchi, Chengnoi, Dist: Nalbari	11	1	12	Pond Aquaculture
9	05.03.2021	Vill: Sandha, Dist: Nalbari	10	0	10	Seed Production
10	10.02.2021	Vill: Dimoria, Dist: Kamrup (M)	19	3	22	Pond Aquaculture
11	08.09.2021	Vill: Sutarpur, Nilbagan, Dist: Nagaon (Undivided)	12	0	12	Seed Production
PRA						
1	10.09.2021	Vill: Bagibari, Sonapur, Dist: Kamrup (M)	31	5	36	Pond Aquaculture

About WorldFish

WorldFish is a nonprofit research and innovation institution that creates, advances and translates scientific research on aquatic food systems into scalable solutions with transformational impact on human well-being and the environment. Our research data, evidence and insights shape better practices, policies and investment decisions for sustainable development in low- and middle-income countries.

We have a global presence across 20 countries in Asia, Africa and the Pacific with 460 staff of 30 nationalities deployed where the greatest sustainable development challenges can be addressed through holistic aquatic food systems solutions.

Our research and innovation work spans climate change, food security and nutrition, sustainable fisheries and aquaculture, the blue economy and ocean governance, One Health, genetics and AgriTech, and it integrates evidence and perspectives on gender, youth and social inclusion. Our approach empowers people for change over the long term: research excellence and engagement with national and international partners are at the heart of our efforts to set new agendas, build capacities and support better decision-making on the critical issues of our times.

WorldFish is part of One CGIAR, the world's largest agricultural innovation network.

For more information, please visit www.worldfishcenter.org