ACT CCIP

ACTION ON CLIMATE TODAY

Assessing
Community Climate Risks
in Majuli

Draft Report

June 2017

“Majuli, the first island district of India, is **under threat from recurrent river bank erosion and flooding.** Climate change is expected to exacerbate the magnitude of these events. **A deep understanding of climate risks and climate proofing of development actions is imperative** for the sustenance and growth of the island’s economy, the well-being of its inhabitants and the preservation of its unique socio-economic and cultural heritage.”

Photo Credit: Chhaya Bhanti, Vertiver

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About the Authors

Sumana Bhattacharya

Dr. Sumana Bhattacharya has 20 years of experience of developing, implementing & managing projects and programmes in the area of climate change. In addition, she has been engaged on climate change policy, finance and governance issues at National and State levels in India. She is a lead author of the IPCC guidelines 1996 and 2006. She has drafted several State Action Plans for Climate Change (SAPCC).

Swapan Mehra

Swapan is an environmental finance and policy expert, proficient in designing and implementing projects and policy interventions in forestry, biodiversity conservation, and climate change mitigation and adaptation. In 2009, he set up IORA, an environmental policy advisory group that provides implementable solutions in the areas of carbon finance, forestry and biodiversity conservation and new market mechanisms for emission reduction.

Rebekah Singh

Rebekah is a climate change adaptation analyst . She also has experience in GHG emission estimations for various sectors. Rebekah holds a Master's degree in Natural Resource Management from GGSIPU, New Delhi and a certificate for a course on 'Water Cooperation' by UNDDD (United Nations Decade for Deserts and the fight against Desertification).

Editorial Team

Dr. Cristina Rumbaitis del Rio, Vidya Soundarajan, Rumita Choudhury, Rizwan Uz Zaman, Rashmi Dutta Dey, and Manoshi Goswami

Corresponding Author

Sumana Bhattacharya. e-mail: sumana@ioraecological.com

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This Work was carried out by IORA Ecological Solutions Private Ltd. with the support of Action on Climate Today (ACT) under DFID- Climate Change Innovation Programme. ACT in Assam supporting the district of Majuli, Assam to identify the vulnerability of its communities to hazards such as floods and riverbank erosion based on a clear understanding of potential climate related impacts on the same and promote climate resilient development i.e. Climate proofed planning and innovative actions. The main objective is to suggest actions that can be developed into full-fledged schemes for the government to implement with funds from their own schemes and also attract climate financing from other sources in order to ameliorate the critical impacts of climate change on different aspects of. ACT also helps raise finances, assist in planning to enhance climate adaptation spend and reduce loss and damage. Institutional strengthening, capacity building are the key enablers of ACT's strategy.The Author Gratefully Acknowledges the department wide discussions with key officials and other Key Informants on the identification of risks, the extent of impacts and the strategies to ameliorate the same.

Majuli Photos Credit: Chhaya Bhanti / Vertiver

Photo Credit: shutterstock.com

Foreword

Majuli is an island within the Brahmaputra River thatoccupies an area of 524.29 sq. km with a population exceeding 160,000 inhabitants. Majuli achieved the status of Assam's newest district in September 2016. Given its location and geo-physical characteristics, Majuli faces recurrent floods and river bank erosion.

Climate change can further aggrayate these risks to Majuli significantly. Mainstreaming climate adaptation actions in the development of the Island remains a key need and priority of the District and State Administrations. Concrete actions need to be taken to make Majuli climate risk resilient for the long term.

I am happy to note that the present study, conducted by our partners IORA Ecological Solutions under the aegis of DFID's Climate Change Innovation Programme(CCIP), identifies climate risks and suggests department wise actionable interventions, which if implemented within Majuli can increase the climate resilience and community adaptation in Majuli. Some of the identified interventionsare already being implemented at a pilot scale but now need to be scaled updistrict wide. The study also identifies potential sources of innovative finance. We look forward to leveraging these and forging public private partnerships to achieve our vision of a climate resilient Majuli.

Pallav Gopal Jha
Pallav Gopal 17.10.17
District Magistrate, Majuli
October, 2017

Executive Summary

Background and Objective

Majuli, an island within the Brahmaputra River in Assam, is the largest river island in the world, and is currently awaiting a UNESCO World Heritage Site declaration. Majuli is home to a rich and unique biodiversity, typical of an island isolated from the mainland and features a diversity of socio cultural and ethnic groups. Majuli was declared a new district in September 2016, and that has contributed to new developmental projects being assigned and will likely lead to a spike in population in the district. Majuli faces recurrent floods (see figure below for extent of flooding in recent years) that annually damage property, crop produce and livestock and disrupt livelihoods. The river banks of Majuli are highly erosion prone and the force of the river currents constantly cut away at its landmass. The Island shrunk from being as large as 734.0 sq km in 2014, to a mere 524.29 sq km[1] in 2016. Government interventions by way of erosion control dykes and embankments efforts led by the Brahmaputra Board and Water resource department have offered some gain in land, however the Majuli's eroding landmass still remains a formidable challenge. Given the changing climate and scientific projections that indicate intensification of flooding events in the future (See Table along side[2]), which among other impacts will also lead to further erosion of the island's landmass, the present study intends to support decision makers towards designing strategies for Majuli that can build resilience to flood and erosion risks and enable climate change adaptation. **The study focusses on assessing community risks to floods and erosion in different Gram Panchayats in Majuli, and provides recommendations towards adaptation for key risks.**

Table: Monthly average projections of temperature, evapotranspiration, precipitation, Evapotranspiration, Rainfall and Runoff Implications of Climate Change for Benefit

Monthly average	2050s	2100
Temperature	1.3-2.4°C	2.0-4.5°C
Evapotranspiration	5-8%	7-36%
Rainfall	+14-15%	-28 to +22%
River runoff	-1 to +15%	+5 to 20%

[1] Bramhaputra Board, 2016. Citizens Charter of Bramhaputra Board. http://www.brahmaputraboard.gov.in/NER/Archive/citizen_charter.pdf

[2] IUCN, 2014. A Physical Assessment of Bramhaputra River. Published by International Union for Conservation of Nature. Available at: http://cmsdata.iucn.org/downloads/iucn_research_brahmaputra_basin.pdf.

> Extreme hydro-meteorological events (e.g. droughts, floods, extreme heat) **lead to climate risks for communities, disrupting their normal lives.** The recurrence of these events creates a spiral of climate vulnerability.

Methodological Framework

A detailed risk assessment would ideally involve an analysis of historical climate trends and projections of future changes in climate to determine extreme hydrological events and hazards in the past and the possibility of them recurring in the future. This assessment is accomplished through climate modeling and biophysical modeling, which involve substantial time. To come up with a risk assessment rapidly, we have relied on stakeholder consultations through Focus Group Discussions (FGDs) with community members to identify the impacts of major hydro-meteorological risks to Majuli. We have also used literature survey to supplement this assessment.

Assessment of Risks and Consequences

The risks and level of risks for all the 14 Gram Panchayats have been analysed based on the responses received during the survey. Results are presented in Table below. The risk perception is high in flood and erosion prone areas in Majuli and the perception of risk is low in areas where the flooding is relatively rare and are located in the upper reaches of Majuli.

	Bongaon	Dakhin Kamlabari	Dakhinpat	Pokajora	Kamlabari	Rawanaper
Displacement	H	H	H	L	M	L
Livelihood diruption	H	H	H	L	H	L
Propensity towards poverty	H	H	H	L	M	L
Crop and livestock loss	H	H	H	H	H	H
Food security	M	M	M	M	M	M
Potable water	H	H	H	H	H	H
Health and wellbeing	H	H	H	H	H	H
Access to electricity	M	M	M	M	M	M
Access to energy for cooking	H	H	H	H	H	H
Risk to infrastructure	M	M	M	M	M	M
Gender and floods	H	H	H	M	M	M
Overall Risk	**H**	**H**	**H**	**L**	**M**	**L**

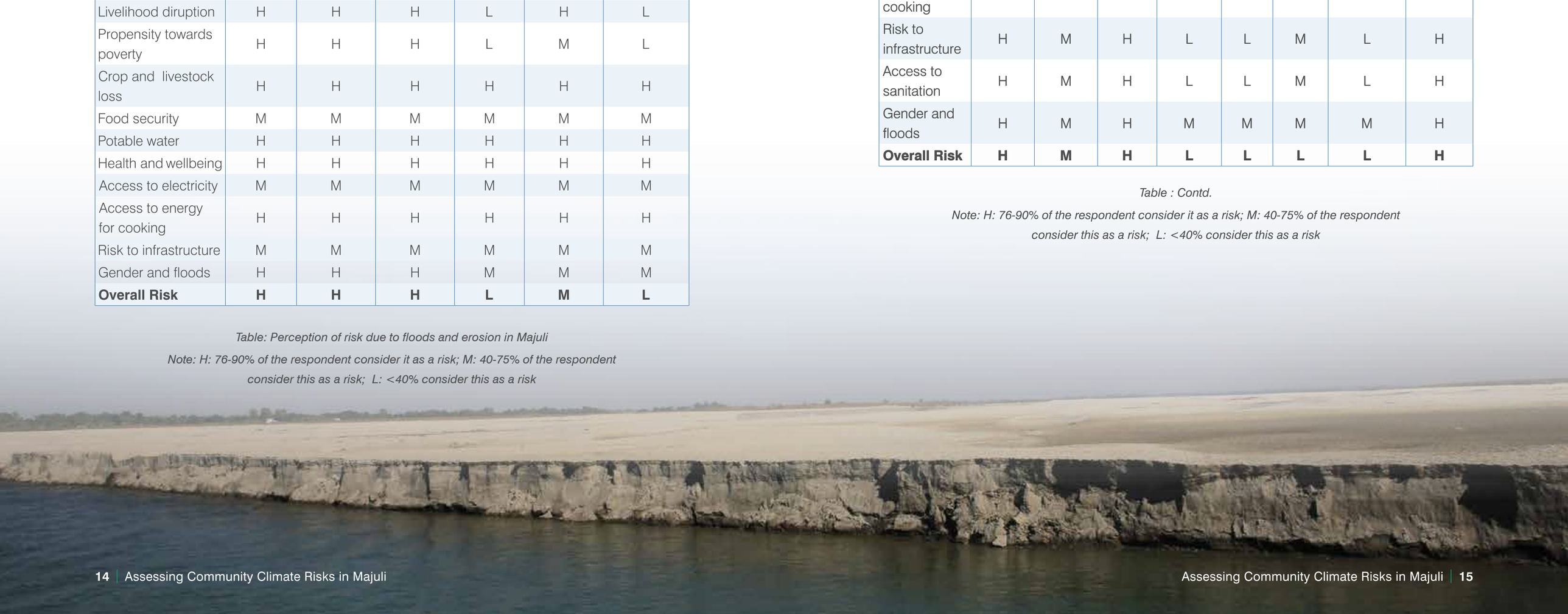
Table: Perception of risk due to floods and erosion in Majuli

Note: H: 76-90% of the respondent consider it as a risk; M: 40-75% of the respondent consider this as a risk; L: <40% consider this as a risk

	Ahatguri	Dakhin Ahatguri	SriLuhit	Garamur	Sriram	Jengrai	Rengchahi	Ratanpur
Displacement	H	M	H	L	L	M	L	H
Livelihood disruption	H	M	H	L	L	L	L	H
Propensity towards poverty	H	H	H	L	L	L	L	H
Crop and livestock loss	H	H	H	H	H	H	H	H
Food security	M	M	M	M	M	M	M	M
Potable water availability	H	H	H	H	H	H	H	H
Health and well-being	H	H	H	H	H	H	H	H
Access to electricity	M	M	M	M	M	M	M	M
Access to energy for cooking	H	H	H	H	H	H	H	H
Risk to infrastructure	H	M	H	L	L	M	L	H
Access to sanitation	H	M	H	L	L	M	L	H
Gender and floods	H	M	H	M	M	M	M	H
Overall Risk	**H**	**M**	**H**	**L**	**L**	**L**	**L**	**H**

Table : Contd.

Note: H: 76-90% of the respondent consider it as a risk; M: 40-75% of the respondent consider this as a risk; L: <40% consider this as a risk



A summary of the risks and associated consequences interpreted as a result of the survey undertaken in 14 Panchayats across 64 villages through FGDs is presented below.

Risks	Consequences
Displacement	• 70-90% of population is displaced due to erosion and floods during monsoon • About INR 2-5 lakhs lost in land and housing • Inwards migration and outward migration happens during floods • Larger settlement sizes formed requiring services that are not adequate at the moment • Displaced people settle along embankments and PWD roads in traditional houses
Livelihood disruption	• About 82% of the livelihoods are at risk due to floods majority of which includes farmers, labourers, weavers, potters, boat makers. • The livelihoods that are safe are the ones who are in service
Propensity towards poverty	• Displaced families become agriculture labourers • Work is only available during the dry season from November to May
Loss in crop and livestock	• Sali crop grown over 13000 ha is lost completely during high floods, so is the Ahu rice grown over around 6000 ha. • Bao, the deep water rice is safe during floods • Boro rice grown during Nov to May is also safe from floods • Livestock loss is high as difficult for them to be carried from long distances to safe places on the embankment
Food security and nutrition	• At stake. Rice stored within HHs not sufficient. • Prices of food items go up by 30-40% • Vendors hoard food and food becomes scarce during floods unless people reach shelters where free food is available • Fish availability also reduces as fish flow away with floods
Potable water availability	• Potable water becomes scarce as direct to home water supply is available only in 1% of the surveyed population • Water consumed in general is boiled rainwater, flood water and in some cases ground water where tube wells exist on high grounds • Rainwater and flood water have high pollutant content as they get contaminated with air pollutants and fecal matter respectively • The ground water is also contaminated in Majuli has high it has high arsenic content which is irrespective of floods
Health and well being	• Diarrhea, Leptospirosis, Viral fever, malaria, jaundice, skin allergy, snake bite and electrocution are some of the health hazards during floods
Access to electricity	• 83% electrifies households in Majuli also face outages during floods that last between few days to weeks. • The line from Lakhimpur supplying electricity gets disrupted
Access to energy	• Clay base cook stoves set up on floors of houses unusable • LPG connections though available in 38% of the houses but not able to access electricity due to heavy floods • Most use firewood stored in attics of the houses in tin based stoves
Risk to infrastructure	• Houses swept away with erosion • Stilt based bamboo houses (Chang Ghar) survive in floods but become unlivable when flood waters rises upto the floors of the houses
Access to sanitation	• About 73% of the HH in surveyed areas do not have access to toilets • The houses that have access to toilets private or public have issues of drainage during floods. • As it is there is not sewage system operational in Majuli
Gender and floods	• Children miss schools and for BPL families that is the one time when they are properly fed. Even pregnant women from such families are fed during mid day in schools. • Earning from weaving is affected due to flooding as the weaving looms are generally placed in the stilt areas below the houses of the tribal' s • Women's health vis a vis prenatal, childbirth, and post natal care is an issue during floods

Table: Risks identified and its consequences

Institutional Adaptive Capacity

Strong scientific, government and community institutions form the backbone of the adaptive capacity of the people of Majuli. These are listed below.

Institution	Adaptation support provided and Lacunae identified in their effectiveness
NESAC (North Eastern Space Application Centre	• Provides early warnings which are issued by the government on Facebook page of the administration, on television and by SMS • But only 56% of the population has access to smart phones and • 39% of population has access to television. Therefore the warning does not reach instantaneously to all.
Educational Institutions	• Education levels in Majuli are high • Primary schools are present in all villages • Secondary level education is also present in a cluster of villages • Colleges are present in village clusters • 71% of the population is educated enough to perceive the technologies and practices that need to be endorsed to adapt to changes
Health infrastructure	• 3 hospitals, 3 mobile vans, 4 PHCs and 4 CHCs exist in Majuli • But in respondent areas, presence of 2 hospitals, 2 PHCs and 2 Dispensaries have been mentioned • Not adequate for a population of 1.7 lakhs
Community institutions	• Village development committees, Panchayats, Joint liability groups, Self Help Groups (SHGs), Mahila Mandal, Watershed committees, VFC (Village Forest Committee)/JFMC (Joint Forest Management Committee) /EDC (Ecological Development Committee) are the community institutions operational in Majuli • SHGs, Youth Groups and Village development committees meet often and therefore can be mobilized quickly for relief during floods • Banks in Majuli are few. Their services do not extend to villages. Therefore some times their services are not available in the post disaster phase.
Awareness campaigns on flood preparedness	• Held regularly before flooding season • Advise on dos and don't provided to people • Advisors include officials from various departments, namely, water resources, agriculture, health, rural development etc.
Majuli disaster Management Plan	• A disaster management plan is in place • Provides guidance to the administration on disaster preparedness and actions to be taken during disaster and post disaster

Recommendations for Building Climate Resilience

Some suggestions evolving out of the assessment are stated below.

Strategy	Action	Funding requirement	Funding Source	Responsible Department in Majuli
Strengthening early warning communication and awareness	Launch a 24x7 FM radio station that will, in addition to entertainment, provide seasonal, 15 day, 7 day, 72 hrs, 48 hrs and 24 hrs forecast of rainfall	Establishment cost INR 0.20 Cr. Annual costs to be borne through advertisements.	Grant from Ministry of Information and Broadcasting	District Administration
Ensuring food security	Promote Bao rice or floating rice and connect it with organic certification to encourage farmers to grow rice during the rainy season with market connect.	Training on organic certification process (INR 0.10 Cr per year for 5 years)	NABARD	Agriculture Department
	Increase cultivation of Boro rice during the dry season from November to May from 5500 ha to 10,000 ha by 2020 through improved irrigation.	Additional 350 Solar pump sets to be installed (INR 371.60 Cr)	Department of Agriculture Engineering	Pradhan Mantri Krishi Vikas Yojana
Sustainable livelihoods	Support development of a responsible ecotourism industry	Train 100 youth till as ecotourism guides and ecotourism entrepreneurs by 2020 (INR 7 Cr)	Tourism Department	Pradhanmantri Kaushal Vikas Yojana
	Enable conversion of at least 100 manual looms annually till 2020 to solar power looms with support of new designs and establish value chains of their products to ensure sustained monthly income	Cost expected to be INR 4.16 Cr	Department of Textiles	JNNURM

	Develop a bamboo design centre in Majuli and conduct design research and training for various artefacts	Cost expected to be INR 0.10 Cr per annum	Forest department	Assam State Bamboo Mission
	Create 1000 habackyard bamboo plantations by 2020 with financial incentives for survival.	Cost expected to be INR 4.8 Cr till 2020	Forest Department	Assam Bamboo mission
	Promote Majuli made canoe's as indigenous products of Majuli	Create a training centre for traditional canoe making and train 100 youth till 2020¬¬. Cost expected to be INR 0.10 Cr/ annum	Majuli Administration	Skill Development Mission
	Create Majuli brands for its indigenous pottery and mask making	Create a training centre for traditional pottery making with a design centre attached to it and train 100 youth till 2020. Cost expected to be INR 0.15 Cr/ annum	Majuli Administration	Skill Development Mission
Ensuring potable water availability	Fast forward access to river water- Bramhajal project	Cost expected to be INR 4.8 Cr till 2020	PHED	
	Extend Brahmaputra piped water accessibility to all HHs in Majuli	Needs to be estimated		
	Training and deployment to HHs to convert turbid and contaminated rainwater into potable water: NEERIs Portable Instant Water Filter "NEERI-ZAR"	For all HHs Total cost for procuring NEERI-ZAR is INR 8.44 Cr	Jalmani Programme of Ministry of Drinking water and sanitation	PHED
Housing Security	Design and implement 5000 flood resilient housing (813 beneficiaries already identified)	Cost estimated at INR 45 Cr	Pradhanmantri Awaas Yojana	Department of Rural Development

Proposed Next Steps

To carry this assessment further, it is proposed that each of the recommendations be run through the district administration for their inputs and acceptance. Further, for the set of recommendation's accepted, full-fledged project design documents (PDD) should be formulated for funding. If necessary, policy support can be provided for integrating the recommendations provided in this document, within the ongoing programs of the government, such as building climate resilient indigenous houses with funds from Pradahan Mantri Awas Yojana.

1. Introduction

Majuli is a very socio-culturally unique place, serving as the seat of Assamese vaishnavite culture. The island is also home to rich biodiversity, which also serves as the breeding ground for various migratory birds. Since Majuli was declared a district in September 2016, an array of infrastructure developmental projects have been announced (See Box 1) and some have already been launched. The scale of development envisaged for the newly formed district is unprecedented for Majuli, as it was only a sleepy rural subdivision of Jorhat until recently. The planned developmental activities may disrupt Majuli's pristine rural setting, its unique biodiversity and natural resource based livelihoods.

In view to preserve the unique biodiversity of Majuli, the island was declared a Biodiversity Heritage Site by the Assam Biodiversity Board in December 2016. Further, the Government and IORA Ecological Solutions have launched the Sustainable Actions for Climate Resilient Development (SACReD) program, for making Majuli Carbon neutral by 2020 while building the climate resilience of the Island and maintaining its socio-cultural-biodiversity heritage. Under SACReD the following activities have been planned:

1. **Distributed Renewable Energy (DRE) generation projects to cater to the increasing energy demand of the island;**
2. **Green sustainable integrated transport system;**
3. **Green norms for buildings and surrounding landscapes;**
4. **Waste recycling mechanisms leading to zero waste emissions;**
5. **Efficient water use and carbon neutral packages for practices in agriculture; and**
6. **Afforestation across Majuli landscape amongst others.**

Photo Credit: Daniel J. Rao / Shutterstock.com

Box1: Development projects announced in 2016 in Majuli

Since the declaration of Majuli as a district in 2016, the island has received numerous proposals for development. Some of the development proposals as indicated by the administration are as follows:

- Integrated Office cum Residential Complex for 35 Departments which is likely to be completed by 2020
- Many other institutional buildings, Universities, Schools, Hospitals, Skill development centres, Planetarium, Police Stations, and Auditoriums)
- Reverse Osmosis (RO) cum Sanitation complex
- Helipad
- Solar Park (14 MW)
- Fourteen Solar Microgrids (10-63 KW)
- River water extraction plant (Bramhajal)
- Granary (3000-5000 MT)
- Street lighting (40 km)
- Street Lighting along 80 kms of Majuli roads
- Silos- 1000 metric tons
- Completion and upgradation of Circular Road as an embankment surrounding Majuli
- Bridges over Brahmaputra connecting Majuli with Jorhat and Lakhimpur

Given its location within the upper reaches of river Brahmaputra between the intake point of "Kherkatia Suti" in the east, and outfall of Subansiri River in the west, Majuli faces annually recurring floods. Additionally, due to the braided nature of flow of the Brahmaputra river, Majuli's banks along the river are erosion prone.

Due to these hazards, the people of Majuli continually suffer displacement, loss of assets and livelihoods which are mainly natural resource dependent. Projections suggest that the hazard intensity is likely to escalate further in a warming scenario (IUCN, 2014)[4]. Damages experienced by Majuli and assessed by the Brahmaputra Board between 1988 and 1999 indicate that in some years floods affected all villages, with almost the entire Majuli population incurring huge losses. The flooding period has extended from a few days to six months (see Table 1).

River Bank Erosion-Majuli. Courtesy: NELlive.in

[4] IUCN, 2014. A Physical Assessment of Bramhaputra River. Published by International Union for Conservation of Nature. Available at: http://cmsdata.iucn.org/downloads/iucn_research_brahmaputra_basin.pdf

Year	Affected area in hectares	Number of villages affected	Population affected in thousands	Cropped area affected in hectares	Number of cattle head lost	Total loss due to flood Rs in Lakhs	Period of flooding
1988	1,00,000	255	1,20,000	3657	4500	351.675	NA
1989	650	11	3081	37	NIL	0.924	NA
1990	8000	50	20,000	672	NIL	37.899	NA
1991	80,000	200	1,00,000	4590	987	510.15	NA
1992	33,000	65	30,000	40	Nil	391.15	June to Aug
1993	17,000	60	60,000	10,500	Nil	200.75	4th Aug. to 31 Aug
1994	4380	3	736	NA	Nil	100.2	24 April to 12 July
1995	30,000	110	80,000	9368	Nil	200	May to Sept
1996	60,000	180	1,00,000	18,860	261	2755.98	28 June to 26 July
1997	75,000	150	1,30,000	14,360	20	2259.639	5 July to 16 July
1998	1,50,000	210	1,30,000	70,060	10,000	2912.121	July to Sept
1999	16,000	50	3,00,000	8094	Nil	1561.125	23 June to 28 Aug

Table 1: Estimated damages incurred due to floods in Majuli

Source: Majuli Master Plan-1998, Brahmaputra Board, Vasista, Government of Assam

The Government of Assam is concerned about the flood proneness and bank erosion that is leading to devastating impacts on city infrastructure and the agriculture economy of the rural areas along Brahmaputra. Assam State Action Plan on Climate Change(ASAPCC) has identified several strategies that include research to understand the cause of flooding and river bank erosion and on implementation of appropriate strategies to ameliorate the impacts in the long term. The total cost estimate for undertaking these action is INR 2282.40 Crores. The cost also covers adaptation actions for Majuli.

> “Because of its peculiar location amidst the active floodplains of the Brahmaputra, **Majuli gets inundated not only in severe floods but also in normal floods.**[5]”

Photo Credit: Chhaya Bhanti, Vertiver

[5] http://majulilandscape.gov.in/geography.php

2. Objective of the Assessment

Some climate related risks created by a range of hydro-meteorological hazards are slow in their onset (such as changes in temperature and precipitation leading to droughts), while others happen more suddenly (such as tropical storms and floods). The past and current experiences of climate related impacts are useful in dealing with climate variability and extreme events, irrespective of attribution to climate change as they hold valuable lessons for reducing vulnerability and enhancing resilience in the face of future climate-related adverse impacts. Within this context, the objective and scope of this assessment for Majuli is defined as follows.

Overall Objective

The objective of the report is to support decision makers towards designing strategies that build resilience to flood and erosion risks and ameliorate the resultant impacts even in the context of climate change which increases the likelihood of the occurrence of floods and erosion.

Immediate Objective

To assess the risks to communities in different Gram Panchayats in Majuli from floods and recurrent erosion and provide recommendations towards adaptation for key risks.

Report Structure

1. **Introduction**
2. **Linking Hazard Risk and Climate Change**
3. **Methodology for Risk Assessment**
4. **Majuli Profile**
5. **Floods and erosion trends in Majuli**
6. **Assessing Majuli's climate risk**
7. **Recommendations**

3. Linking Hazard Risk and Climate Change

Extreme hydro-meteorological events (e.g. droughts, floods, extreme heat) lead to climate risks for communities disrupting their normal lives and their recurrence is a climate risk. The events become disasters when they cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and natural resources. As per the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC ARV, 2013)[6], probability of intensification of such extreme events may increase and in a warming climate pose a greater threat to the communities not prepared adequately. Disaster risk management becomes climate resilient when long term preparedness is factored in to manage the expected level of risks.

Definitions of some key climate risk adaptation terminologies in the context of Majuli are as follows:

Exposure

Exposure relates to entire Majuli, its population, natural resources (water resources, agriculture, livestock, fisheries, vegetation, other flora and fauna), infrastructure (houses, roads and embankments), livelihoods of people, and its culture.

Sensitivity

In case of Majuli, sensitivity of the communities will be direct as well as indirect. Example of direct sensitivity is change in crop yield in

Photo Credit: Chhaya Bhanti, Vertiver

[6] IPCC ARV, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

response to a change in the mean temperature, or variability of temperature. An example of indirect effects is the damages caused by an increase in the frequency/intensity of flooding and consequent bank erosion.

Adaptive capacity

In case of Majuli, it would be flood and erosion resilient roads and embankments, flood and erosion warning, rapid and easy access to disaster recovery support, consistent awareness and capacity building on preparing to manage disasters,- diversified livelihoods with less dependence on natural resource based livelihoods, techniques to ensure food security, water security, and community support and risk insurance to hedge risks.

Vulnerability

Vulnerability is the propensity or predisposition to be adversely affected. Climate vulnerability is a combination of the possible impacts caused by exposure and sensitivity to the climate, and the capacity to adapt. It usually refers to harmful or unwanted consequences. Combining climate vulnerability with the likelihood of an event results in climate risk.

Climate Risk

is the likelihood that the harmful effects of climate change will happen. It is a function of probability of climate hazard and the consequences (usually seen as losses) that would arise if the events took place. In case of Majuli, floods are associated with risk of crop loss, livelihood loss, income loss etc. on a regular basis and the damages may escalate as further warming of the atmosphere takes place leading to occurrence of more severe floods.

Disaster

The likelihood of severe alterations, over a specified time period in the normal functioning of a community or a society due to hazardous physical events interacting with vulnerable social conditions, leading to widespread adverse human, material, economic, or environmental effects that require immediate emergency response to satisfy critical human needs and that may require external support for recovery. Severe flood events and river bank erosion are disasters that alter the regular lives of people of Majuli.

Photo Credit: Chhaya Bhanti, Vertiver

4. Methodological Framework for Risk Assessment

A risk assessment would ideally involve an analysis of the historical climate trends and projections of the future climate to understand how the hazards or extreme hydrological events have panned out historically or likely to pan out in the future. A modelling approach would help to understand the exacerbated impacts of climate change on various systems to ascertain the risks associated and substantiate these findings through a socio-economic survey. The next step would be to crystallize the impacts, rank them and look for ways to plan to abate the most hazardous impacts and adapt to the projected change.

Since this would involve substantial time, we have relied on a rapid risk assessment through stakeholder consultations to identify the major hydro-meteorological risks to Majuli. The stakeholders include various government departments that are operating in Majuli. We have also undertaken a literature survey to characterize the hazards (extreme climate events) and conducted socio-economic surveys to identity the associated risks. Figure 2 indicates the methodological framework for a rapid assessment of climate induced risks associated with flooding and erosion in Majuli.

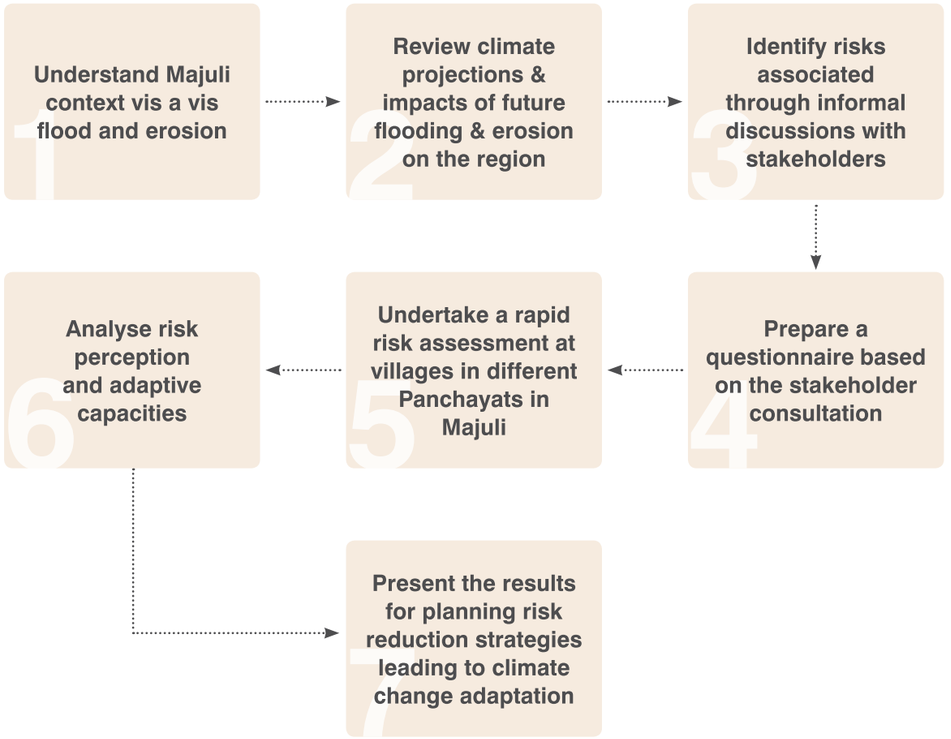


Figure 1: Methodological framework for a rapid assessment of climate risks associated with floods and erosion in Majuli

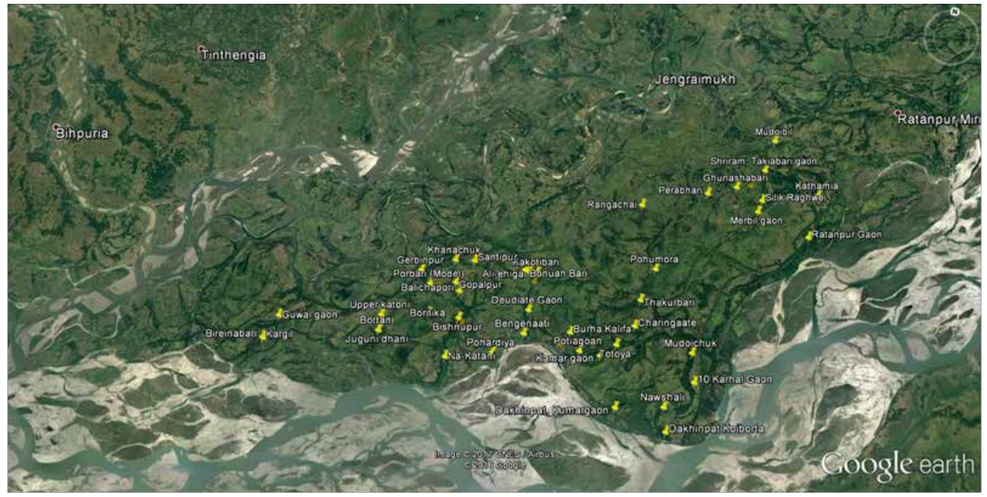


Figure 2: Location of villages surveyed across the 4 blocks in Majuli (to be updated)

The survey was carried out in Majuli across 64 villages in and around Majuli's 32 Satras, covering 14 Gram Panchayats to understand the climate risk perception of the communities associated with floods and erosion during April/ May 2017. Satras are the cultural and religious institution that are the seat of Assam's Neo-Vaishnavite culture since the 15th century and exert deep influence on the decision making of surrounding communities. The location of the villages is indicated in the spatial map of Majuli in Figure 3. List of the villages surveyed and the Gram Panchayats and blocks they are located in is given in Annexure 2.

A questionnaire was formulated and used (Attached in Annexure 1) to assess the exposure, impacts, adaptive capacities, vulnerability and hence climate risk of the different blocks. The questionnaire was validated with the concerned stakeholders including the District Commissioner and the various Departmental heads that manage floods and erosion and whose works are impacted by the same, along with explanation about the objective of this assessment. Focus group discussions (FGDs) were carried out in each of these villages, with key informants that included the gram panchayat head, women representative from various SHGs, and with key functionaries of various committees in the villages.

FGD Boritika village

FGD at Riatigaon

FGD at Dakhinpat KalitaGaon

FGD at Bortani village

5. Majuli Profile

Geography

Majuli is located at latitude of 26°45'N-27°12'N and longitude of 93°39'E- 94°35'E and covers an area of 524.29 sq km (Brahmaputra Board, 2016)[7]. It is located at an elevation of 85-90 m above mean sea level within the Brahmaputra river. The north and south banks of the river Brahmaputra have wetlands-a characteristic feature of the hydrology of the system. They are locally known as Beels and are the breeding grounds of rich flora and fauna unique to this region. The island is separated from the mainland Assam by 2.5 km and can be approached from Neemati Ghat in Jorhat district to the south of the island by ferry reaching Kamalabari in Majuli. The other mainland towns in proximity to the island on the north bank are north Lakhimpur and Dhakuwakhana.

Particulars	Total
Total Population	17.07 lakhs
Number of blocks	2
Number of villages	246
Rural Population	100%
Number of gram Panchayats	20
Family size	5.2
Female per 1000 male	957
Literacy	74%
Non agricultural workers	3.25%
Agricultural Labour	22.75%
Agricultural Workers	74%
SC Farmers	4734 (13.75%)
ST Farmers	16979 (49.36%)
General Farmers	12697(36.89%)
Women Farmers	19989
Number of villages	246
Sattra's	31

Table 2: Socio-economic profile of Majuli

Source: Data provided by Agriculture Department

Population

As of 2016, Majuli's population is 1,70,650 with a population density of 323 per sq km[8]. About 23% of the total population constitutes of Scheduled Tribes. Scheduled Caste population is about 14% and the rest of the population falls under general category (Census, 2011). The island is inhabited by various communities. Amongst them, the Koch, Kachari, Chutia, Mishing, Deori and Ahom belong to the Burmese branch of the Mongoloid origin. The Kaivartta, Matak, Nath, Keot etc. are of Dravidian origin. Kalita and Brahmins are of Aryan origin. The non-tribal communities include Kalita, Koch, Nath, Chutiyas, Kaivartas, Baniyas, Keots, Brahmins, Sut and Ahoms. The rest of the population belongs to the Scheduled Tribes formed by the Mising, the Deori and the Kachari tribes. Because of its predominant tribal population, Majuli was declared a Tribal Constituency[9].

Administrative division

The administrative division of Majuli District comprises of 2 blocks, namely Majuli development Block and Ujani Majuli Block. Within these two blocks are 20 Gram Panchayats and 246 villages[10] and 32,236

[7] Bramhaputra Board, 2016. Citizens Charter of Bramhaputra Board. http://www.brahmaputraboard.gov.in/NER/Archive/citizen_charter.pdf
[8] Data provided by Agriculture Department
[9] Majuli Cultural Landscape Management Authority (http://majulilandscape.gov.in/culture_thepeople.php)
[10] Available at: https://villageinfo.in/assam/jorhat/majuli.html

households reside therein[11]. In 2017, the number of households in Majuli increased to 41,000[12].

Type of habitation

One hundred percent of the population in Majuli is rural—living across 246 villages. A majority of them live in bamboo houses constructed on stilts. Of these, 210 are cadastral villages (revenues generated by the administration and supported with revenue maps) and 33 are non-cadastral villages (villages without revenue maps are mostly resettled or rehabilitated shifted due to flood and erosion in Majuli).

Land use

LANDSAT imagery analysis of Majuli indicates that as of 2015, Majuli had 6284 ha under tree cover, 46922 ha under cropland, 5553 ha under grass land, 3450 ha covered by water bodies. Barren land, fallow land etc. together cover 23387 hectares.

Agriculture land holding

The data shared by the Agriculture department of Majuli indicates that majority (about 48%) of the farmer House Holds(HH) possess <2 ha of agricultural land. Landless farmers constitute only 6% of the total population (See Figure 4).

Livelihoods

Agriculture is the main occupation[13] on the island. Non-agriculture workers pursue weaving, pottery, fishing, boat making, shop keeping amongst other livelihoods. Ecotourism is also catching up in Majuli but is yet to attain its full potential. A minuscule percentage of the population constitutes of government officials, own businesses and also work in private offices.

Economy

Majuli's economy is primarily natural resource based. As per our survey, every household also has a livestock holding of 3-5 cattle, a few pigs and some poultry. Pisciculture, dairying, handloom, boat making and pottery are the other activities pursued in the village. The livelihoods pursued are highly climate dependent and are affected by floods severely. Handloom sector, constituting manual looms owned by all tribal households, and operated only by women thrives in the district. This sector is susceptible to the availability of thread—silk or cotton, from the mainland, though a minuscule plantation drive of mulberry has been initiated in Majuli.

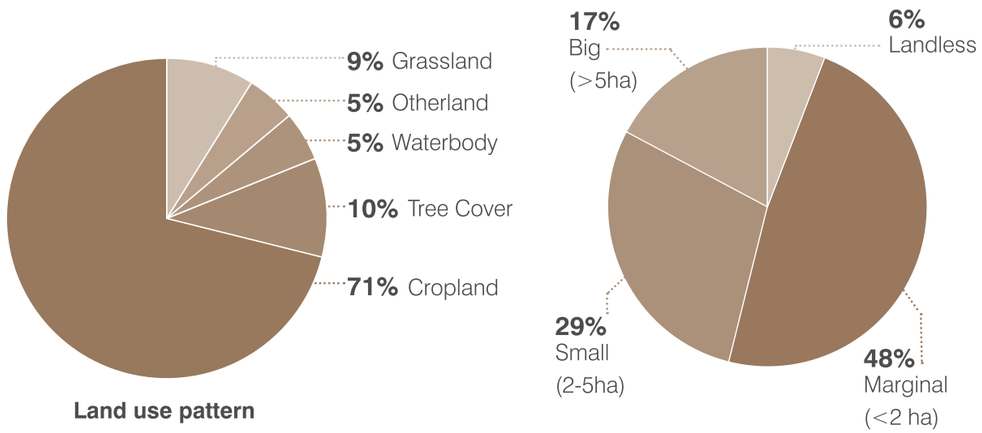


Figure 3: (a) Land use pattern in Majuli in 2015 (LANDSAT) and (b) Agriculture landholding patterns of HHs in Majuli.

[11] Census, 2011.
[12] Data provided by Agriculture and PHED department in Majuli
[13] Data provided by Agriculture Department, Majuli

Biodiversity

In December 2016, Majuli was declared a Biodiversity Heritage Site by Assam Biodiversity Board[14]. It is known for its unique repository of flora and fauna. The island not only supports resident birds, but also attracts migratory birds due to its geographical location and features 260 bird species. It has become home to several endangered species. 20 reptile species, around 10 species of amphibians, thousands of insects and more than 100 types of fish have been recorded on the island. High rainfall[15] and high moisture content in the soil support growth of deciduous trees, grasses, shrubs, bamboo, etc.

Infrastructure

Majuli has a 100 km arterial road surrounding the island, constructed on an embankment. Majuli has 246 villages, most of which have Kutcha roads. The houses are a mix of pure bamboo on stilts with corrugated sheets as roofs and some pucca houses with similar roofs. A major part of the infrastructure includes, Satras - the nerve-centres of the Neo-Vaishnavite religion, art and culture. About 31 Satras or monasteries exist in Majuli that practice this culture and are spread all across Majuli. An office complex with a circuit house/guest house is located at Garamur. The main road of the island is dotted with small shops, with essentials brought from outside Majuli and agriculture produce.

Access to electricity

Majuli is being supplied electricity from a 16.5 MVA capacity electric line from Lakhimpur 132 kV Sub-station[16]. 70% households are electrified. Complete electrification is planned by the year 2022. Of the 22,000 consumers in Majuli who have metered connections, 63% are BPL consumers (JeevanDhara connections–60 W), 33% are domestic (normal) consumers, 3% use commercial connections, and 1% are industrial consumers (numerous rice mill and

Photo Credit: Chhaya Bhanti, Vertiver

[14] https://www.telegraphindia.com/1170225/jsp/northeast/story_137594.jsp, accessed on May 29, 2017
[15] Mean average rainfall over period 1980 to 2004 is 1705mm
[16] APDCL, 2017. Data supplied by Majuli Electricity Department.

3 private oil mills). AT&C (aggregate technical and commercial) loss is about 40% and above, mainly due to hooking of agricultural pumps illegally. There are around 5000 diesel based and 1000 electric agricultural pump sets. There are about 89 street lamps of 10m height each in Majuli with 250 W Sodium Vapour lamps spread across Gormur, Kalambari, Balisobari and in Bangaon.

Climate

Climate of the island is characterized by subtropical monsoon nature with high rainfall, high humidity and general coolness. Four distinct seasons can be identified in the region: pre-monsoon, monsoon, post-monsoon and winter. Heavy rainfall is received during summer and occasional rainfall during winter. January and February are the driest months. Pre-monsoon showers are received during March and April. The heavy rainfall received during summer is influenced by the southwest monsoon. The average annual rainfall for last ten years has been recorded to be 200 cm. The average relative humidity in a year is 78.7 per cent. Average monthly temperature in the area varies between about 29˚C in summer (July-August) and 6˚C in winter (January). Figure 5 presents the average monthly temperature and rainfall pattern.

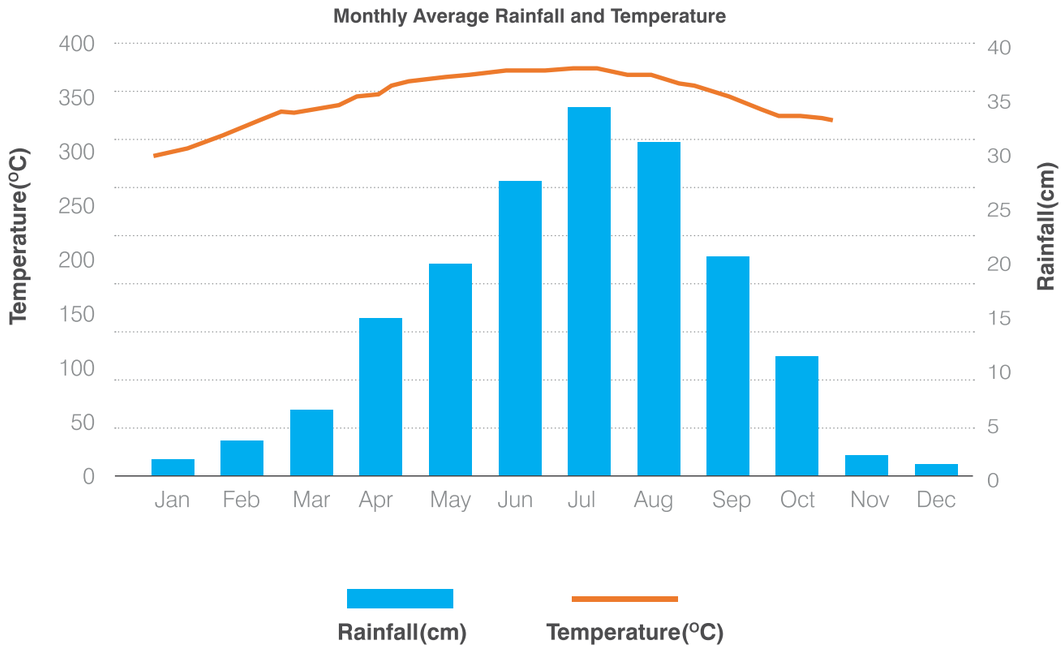


Figure 4: Monthly average temperature and rainfall in Majuli
Source: Statistical Handbook, Jorhat, 2014

6. Floods and Erosion trends in Majuli

6.1 Floods

Majuli is flooded almost every year during the monsoon season (June, July, August and September-JJAS). The flooding period varies from less than a month to four months. A flood prone area map of Majuli (Figure 6) created for its Disaster Management Plan (DMPM, 2014), highlights the highly flood risk prone zones in red, medium risk prone zones in yellow and highlands which are rarely affected by floods in green. The small islet like structures, locally called Chars or Chaporis are part of Majuli District and at high risk to flooding. The district administration has identified about 20 gram panchayats that are flood prone (Table 3). Within these gram panchayats, 13% of the villages are highly flood prone, 37% of them are moderately flood prone and rest have low flooding probability.

Map of Majuli Showing Flood Vulnerability Area

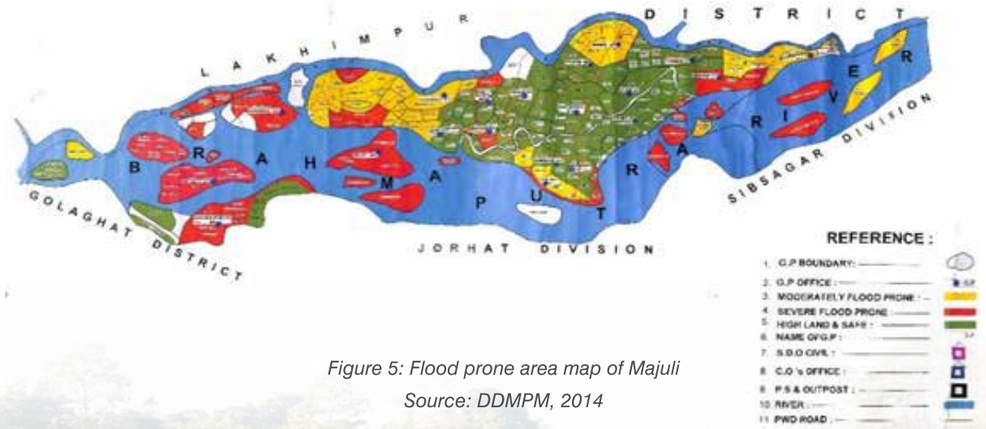


Figure 5: Flood prone area map of Majuli
Source: DDMPM, 2014

[16] APDCL, 2017. Data supplied by Majuli Electricity Department.

Sl No	GP Name	Number of Villages		
		Highlands and Safe	Severe Flood Prone	Moderately Flood Prone
1	RatanpurGaon	8	3	0
2	Jengrai	0	0	6
3	Phulani	8	0	0
4	LuhitParia	3	8	0
5	Rangachahi	12	0	0
6	Siram	8	0	0
7	Charpal	10	0	0
8	Ratanpur Miri	0	15	0
9	Kamalabari	9	1	0
10	Dakhin Kamalabari	4	3	1
11	Karatipar	0	6	4
12	Sri Luhit	0	9	1
13	Garamur	4	1	0
14	Chilakola	0	0	9
15	Dakhinpat	0	2	4
16	Bon Gaon	10	1	0
17	Pokajora	11	0	0
18	RawnaparSamguri	6	1	1
19	DakhinAhataguri	2	5	0
20	Ahataguri	0	17	0

Table 3: List of gram panchayats and villages that are safe and susceptible to floods

Source: DDMPM, 2014[17]

Figure 7 shows the embankment around Majuli. This embankment is often breached and is being continuously repaired by the Water Resources Department and the Brahmaputra Board. Remote sensing based observations for the last 6 years (2011-2016) indicate that Majuli has been flooded each of these years to a different extent, indicating regular breaching of the embankment that lets excess water from Brahmaputra, Tuni and Subansri flood Majuli.

Figures 8 indicates actual days of flooding and areas inundated in the years 2015- 2016 in Majuli. The year 2012 was the most severe flood year when waters had spread all across Majuli and remained there for 4 months (Figure 8b). Table 4 below depicts the extent of loss as recorded by the district at two recent flooding events in 2012 and 2015, representing one year each of extreme flooding and moderate flooding.

[17] DDMPM, 2014. District Disaster Management Plan of Majuli. Available: http://jorhat.gov.in/images/FOrms/DM-majuli.pdf . Accessed on 26th May 2017.

	2012[&]	2015[$]
Total area flooded (ha)	23,171.62	-
Roads damaged	3	-
Habitation impacted		
Villages affected	127	244
Houses damaged and washed away	157	-
Value of loss due to loss in housing (INR)	23,00,000	-
Impact on agriculture		
Number of farm families affected (ha)	-	15705
Cropping area affected (ha)	-	5778.94
Crops affected	Potato, black and green gram, Ahu paddy, Summer paddy (Sali paddy), Bao paddy and vegetables	
Number of cattle lost	138	-
Value of loss in agriculture (INR)	20,00,000	-

Table 4: Losses registered during two recent flood events- 2012 (severe flooding) and 2015 (moderate flood event)

[&]Source:DMPM, 2014, $Source: Agriculture Department, 2016

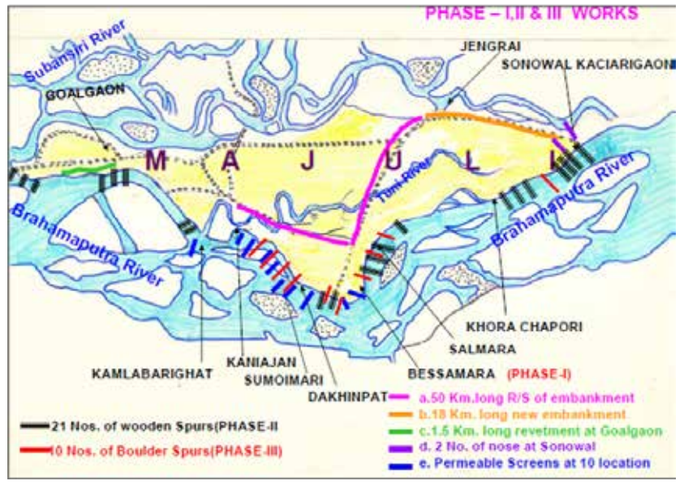


Figure 6: Locations of original embankment and different types of anti-flooding and bank erosion works carried out in Majuli by the Brahmaputra Board in Phase I, II and intended in Phase III.

Source: Aggarwal, 2004[18]

[18] Aggarwal, SK. Member CWC. Presentation on Protection of Majuli island against flood and erosion- A case study. Available at: http://nidm.gov.in/idmc/Proceedings/Flood/B2-%2030.pdf

2011- 17 July to 18th August

2012- June to September

2013- 1st July to 12th September

2014- 16th August to 29th September

2015- 8th July to 26th September

2016- 23rd June to 29th July

Figure 7: Extent of flooding and days of flooding in Majuli in JJAS (June, July, August, September) during 2011 and 2016
Source: Bhuwan Portal. Indian Geoportal of ISRO. Available at: http://bhuvan-noeda.nrsc.gov.in/disaster/disaster/disaster.php

6.2 Erosion

The changing course of Brahmaputra is leading to continued erosion of Majuli's river bank. As a result, many parts of the original Majuli island have been lost. According to the Geological Survey of India, the Island covered an area of 734 sq km in 1914, which was reduced to 502 sq km in 2004[19].

Erosion is the most severe problem affecting Majuli. Severe erosions have happened in areas like Kalambari, Haldibari, Sonowal-Kacharigaon, Salmora, Kamargain, Dakhinpat. Chumaimari, Kaniajan and in Ahatgouri. Several gram panchayats like Ahatguri have lost homesteads, agriculture land, schools and panchayat offices. As not enough suitable land is available within Ahotguri, families are shifting to Golaghat – in the main land or building temporary housing on both sides of the embankment. Figure 6 below shows the erosion prone areas in Majuli as demarcated by the administration.

An analysis of erosion deposition process based on Survey of India (SOI) topo-sheets and Indian Remote Sensing (IRS) satellite imagery for the period from 1966-1975 to 2008 in a Geographical Information System (GIS) environment indicates that in this period, the average annual rate of erosion was almost 5 times more than average rate of deposition in Majuli (8.76 km^2/yr and 1.87 km^2/yr[20] respectively). The actual extent of area eroded in the south bank of Majuli between 1990 and 2008 (marked in blue) was 76.8 ssq km[21]. A map showing extent of erosion between 2004 and 2011 and reclamation of land is depicted in Figure 7. The reclamation has happened due to the efforts of the Brahmaputra Board, which has put in place structural measures such as embankments, geo-bags, porcupines. As a result of the Board's efforts about 22.08 sq km has been reclaimed till 2016. Year to year landmass gained since 2004 is indicated in Table 5.

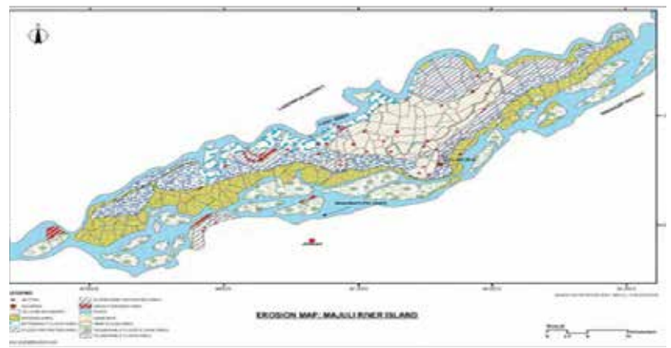


Figure 8: Majuli map showing potential area of erosion in green, highly erosion prone area in red
Source: DDMPM, 2014

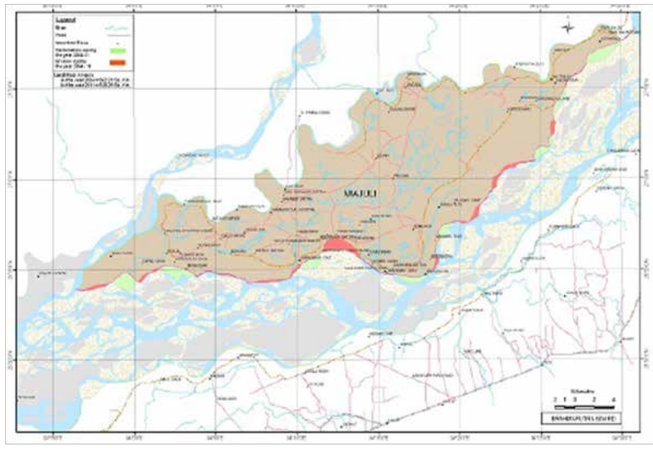


Figure 9 : Area eroded (red) and reclaimed (green) between 2004 and 2011 Brahmaputra
Source: Brahmaputra Board, 2012[22]

[19] http://wrmin.nic.in/writereaddata/Protection%20of%20Majuli%20Island.pdf

[20] Dutta M K, Swapnali Barman and S.P. Aggarwal, 2010. A study of erosion-deposition processes around Majuli Island, Assam. Open access e-Journal Earth Science India, Vol. 3 (IV), October, 2010, pp. 206-216 http://www.earthscienceindia.info/

[21] NDMA, 2012. Study of River Bramhaputra river erosion and its control. Available at: http://www.ndma.gov.in/images/pdf/NDMA Final%20Report%20Brahmaputra%20River.pdf

[22] Bramhaputra Board, 2012. Protection of Majuli Island from flood and erosion. Available at: http://www.brahmaputraboard.gov.in/NER/Archive/report_on_protection_of_majuli_island_from_floods_and_erosion.pdf

Year	Area of Majuli Island (sq. Km.)	Net Area reclaimed(in sq. km)
1914	734.00	-
2004	502.21	-
2008	506.37	4.16
2011	520.26	13.89
2012	522.73	2.47
2014	523.88	1.15
2016	524.29	0.41
	Total area reclaimed	**22.08**

Table 5: Annual and total area reclaimed in Majuli between 2004 and 2016

Photo Credit: Chhaya Bhanti, Vertiver

7. Projected Changes in Climate in the Brahmaputra Basin and impacts on Floods and Erosion

The two major climate risks facing Majuli are floods and erosion. Both are showing signs of intensification. This is corroborated by a paper by Vittal et. al. (2013)[23], indicating increase in extreme rainfall over North East India between 1901-2014. A study using 22 GCMs or Global Climate Models (IUCN, 2014)[24], for the Brahmaputra river basin, indicates that the temperatures in this basin are expected to increase from 1.3˚C to 2.4˚C by 2050, and from 2.0˚C to 4.5˚C by 2100. Monthly evapotranspiration is likely to increase by 5% to 18% by 2050, and by 7% to 36% by 2100, especially in the months of winter. Average change in monthly rainfall are likely to vary from -14% to +15 % by 2050, and -28% to +22% by 2100. Average monthly flow in the Brahmaputra worked out at a downstream station at Chilmari in Bangladesh is expected to change by -1% to +15% by 2050, and by +5% to +20% by 2100. Table 6,7, and 8 below summarize the monthly changes in temperature, evapotranspiration and rainfall projected for 2050 and 2100.

Future Condition	Emission Scenario	Monthly Average Temperature Increase (0C)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2050	A1B	2.38	2.35	2.20	2.23	1.80	1.70	1.71	1.64	1.80	1.98	1.98	2.00
relative to	B1	1.89	1.77	1.70	1.80	1.45	1.38	1.43	1.34	1.45	1.40	1.56	1.60
2000	A2	2.10	2.08	2.08	1.99	1.61	1.51	1.70	1.62	1.63	1.71	1.74	1.85
2100	A1B	3.84	3.80	3.71	3.68	3.07	2.86	2.85	2.79	2.95	3.15	3.34	3.36
relative to	B1	2.82	2.65	2.58	2.65	2.21	1.86	2.02	1.95	2.15	2.25	2.27	2.44
2000	A2	4.43	4.31	4.34	4.16	3.47	3.21	3.13	3.15	3.30	3.55	3.61	3.96

Table 6: Changes projected in monthly average temperature in 2050 and 2100 w.r.t the year 2000 within the Brahmaputra basin

Source: A Physical Assessment of Brahmaputra River. Published by International Union for Conservation of Nature. Available at: http://cmsdata.iucn.org/downloads/iucn_research_brahmaputra_basin.pdf

[23] Vittal, Karmakar and Ghosh, 2013. Diametric changes in trends and patterns of extreme rainfall over India from pre-1950 to post-1950. Geophysical Research Letters. Accessed March 30, 2017. http://onlinelibrary.wiley.com/doi/10.1002/grl.50631/full

[24] IUCN, 2014. A Physical Assessment of Bramhaputra River. Published by International Union for Conservation of Nature. Available at: http://cmsdata.iucn.org/downloads/iucn_research_brahmaputra_basin.pdf

Future Condition	Emission Scenario	Monthly Average Evapotranspiration Change (%)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2050	A1B	17	16	13	10	7	6	7	6	7	9	12	16
relative to	B1	15	11	9	8	6	5	5	5	6	7	9	12
2000	A2	18	15	12	9	7	6	6	6	7	8	11	15
2100	A1B	32	28	21	17	12	11	11	11	12	15	21	28
relative to	B1	23	17	14	12	9	7	8	7	9	11	14	19
2000		36	33	25	19	14	12	12	12	14	17	23	34

Table 7: Changes projected in monthly average evapotranspiration in 2050 and 2100 w.r.t the year 2000 within Brahmaputra basin

Source: A Physical Assessment of Brahmaputra River. Published by International Union for Conservation of Nature. Available at: http://cmsdata.iucn.org/downloads/iucn_research_brahmaputra_basin.pdf

Future Condition	Emission Scenario	Monthly Average Rainfall Change (%)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2050	A1B	-11	8	10	8	11	10	8	14	4	12	2	-7
relative to	B1	-4	-14	-2	-1	7	5	3	8	1	3	3	-13
2000	A2	-13	-5	-2	15	15	5	5	12	3	5	3	-14
2100	A1B	-16	1	9	9	16	18	15	15	10	14	6	-4
relative to	B1	-16	-6	9	0	8	12	7	14	0	12	2	-11
2000	A2	-28	-16	-4	14	18	22	15	20	15	22	-6	-27

Table 8: Changes projected in monthly average rainfall in 2050 and 2100 w.r.t the year 2000 Brahmaputra basin
Source:IUCN, 2014. A Physical Assessment of Brahmaputra River. Published by International Union for Conservation of Nature. Available at: http://cmsdata.iucn.org/downloads/iucn_research_brahmaputra_basin.pdf

The projected changes in climate derived from the GCMs were used as inputs to the GBM (Ganga Bramhaputra and Meghna) basin model, based on MIKE Basin software[25] package (a hydrological model developed by DHI). MIKE Basin has been used to simulate changes in river flows for the three IPCC emission scenarios (IPCC's A1b, A2, and B1 scenarios[26]). The overall increase in flows throughout the year is driven by a significant increase in monsoon flows arising from increased rainfall, higher snow melt rates, and increased run off generating areas (as snow melt zone shifts to higher latitudes due to climate change, revealing more surface areas).

The projections indicate that during monsoon, the average increase in monthly flows (river discharge) is likely to vary from 3% to 11% by 2050 across the three emission scenarios, and by 7% to 17% by 2100. See Table 7. The increase in flows by 2050 concurs with common understanding of climate change impacts in the Brahmaputra Basin. However, the continued increase in flows indicated by 2100 does not support the common understanding that reduction in glacier contributions over the long term would have a decreasing impact on flows.

The Ganges-Brahmaputra basin is highly influenced by extreme monsoon rainfall and flooding (Mirza 2002[27]; Warrick et al., 1996[28]). If climate change results in variations in both the intensity and reliability of the monsoon, it will affect both high and low flows, leading not only to increased flooding but possibly

Yr	Emission Scenario	Monthly Average River Flow Change (%)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008-11	Base (m^3/s)	3885	2803	3031	9154	16894	26718	41230	43360	34016	19727	9008	5692
2050	A1B	9	9	15	13	11	8	7	11	9	9	11	10
	B1	4	3	0	-1	4	3	1	5	3	3	4	4
	A2	6	5	3	13	16	6	3	8	7	6	7	7
2100	A1B	14	13	16	12	13	13	12	13	12	13	15	14
	B1	7	6	11	5	5	7	6	10	6	7	9	8
	A2	17	15	7	9	15	16	13	17	17	19	20	18

Table 9: Monthly average changes in river flow in 2050 and 2100 w.r.t base line flow (2008-11) at a station within Brahmaputra Basin
Source:IUCN, 2014. A Physical Assessment of Brahmaputra River. Published by International Union for Conservation of Nature. Available at: http://cmsdata.iucn.org/downloads/iucn_research_brahmaputra_basin.pdf

[25] https://www.mikepoweredbydhi.com/products/mike-hydro-basin
[26] SRES 2000. Summary of policy makers – Emission scenarios. Published by IPCC. Available at : https://www.ipcc.ch/pdf/special-reports/spm/sres-en.pdf
[27] Mirza M. M. Q. (2002) Global warming and changes in the probability of occurrence of fl oods in Bangladesh and implications, Glob.Env.Change, 12, pp127–138
[28] Warrick, R. A., Bhuiya, A. H., and Mirza, M. Q. (1996) The greenhouse effect and climate change, in: The Implications of Climate and Sea-Level Change for Bangladesh, edited by: Warrick, R. A. and Ahmad, Q. K., Kluwer Academic Publishers, Dordrecht, Briefing Document 1.

also to increased variability of available water, both in space and time (Postel et al., 1996[29]). Therefore, increased water flows during floods and wet seasons cannot be used during the low flow seasons unless large storage systems are in place (Oki and Kanae 2006[30]).

Considering the projections are for the entire Bramhaputra basin, it is concluded that as Majuli lies within this basin, it is expected that the increase in flows(discharge) during monsoon in the future may increase the extent of proneness to flooding in Majuli's and more bank erosion can be expected unless measures are taken that can protect Majuli from the volume of flows and hence strength of flows expected.

Photo Credit: Chhaya Bhanti, Vertiver

[29] Postel S.L., Daily G.C., and Ehrlich P.R. (1996) Human appropriation of renewable fresh water, Science, 271, pp 785–788
[30] Oki t., and Kanae, S., 2006. Global Hydrological cycles and World water resources. Science 313, 1068-1072

8. Assessing Majuli's Climate Risk

Preliminary discussions with the district administration departments in Majuli during inception of this work indicated that the climate related events striking Majuli include storms, floods and river bank erosion. Amongst these, floods and erosion being the most frequently occurring events are the focus of attention for this report. In order to carry out a first order assessment of the potential impacts on the inhabitants of Majuli, a questionnaire based primary survey was undertaken across the island. The survey has been carried out in 14 out of 20 Gram Panchayats, ensuring representation across all regions within Majuli. The level of risks for all the 14 Gram Panchayats have been analysed based on the responses received during the survey. The ranking is presented in Table 10. The risk perceptions are evidently high in areas that are flood and erosion prone in Majuli and the perception of risk is low in areas where the flooding is relatively rear and are in the upper reaches of Majuli.

	Bongaon	Dakhin Kamlabari	Dakhinpat	Pokajora	Kamlabari	Rawanaper
Displacement	H	H	H	L	M	L
Livelihood diruption	H	H	H	L	H	L
Propensity towards poverty	H	H	H	L	M	L
Crop and livestock loss	H	H	H	H	H	H
Food security	M	M	M	M	M	M
Potable water	H	H	H	H	H	H
Health and wellbeing	H	H	H	H	H	H
Access to electricity	M	M	M	M	M	M
Access to energy for cooking	H	H	H	H	H	H
Risk to infrastructure	M	M	M	M	M	M
Gender and floods	H	H	H	M	M	M
Overall Risk	H	H	H	L	M	L

Table 10: Perception of risk due to floods and erosion in Majuli

Note: H: 76-90% of the respondent consider it as a risk; M: 40-75% of the respondent consider this as a risk; L: <40% consider this as a risk

	Ahatguri	Dakhin Ahatguri	SriLuhit	Garamur	Sriram	Jengrai	Rengchahi	Ratanpur
Displacement	H	M	H	L	L	M	L	H
Livelihood diruption	H	M	H	L	L	L	L	H
Propensity towards poverty	H	H	H	L	L	L	L	H
Crop and livestock loss	H	H	H	H	H	H	H	H
Food security	M	M	M	M	M	M	M	M
Potable water availability	H	H	H	H	H	H	H	H
Health and well being	H	H	H	H	H	H	H	H
Access to electricity	M	M	M	M	M	M	M	M
Access to energy for cooking	H	H	H	H	H	H	H	H
Risk to infrastructure	H	M	H	L	L	M	L	H
Access to sanitation	H	M	H	L	L	M	L	H
Gender and livelihood	H	M	H	M	M	M	M	H
Overall Risk	H	M	H	L	L	L	L	H

Table 10: Contd.

Note: H: 76-90% of the respondent consider it as a risk; M: 40-75% of the respondent consider this as a risk; L: <40% consider this as a risk

8.1 Displacement

The respondents indicated that about 70% to 90% of the population is displaced in the villages in areas that are flood and erosion prone. As a result, communities lose their agriculture land, houses, and livelihoods (cropping, dairying, fishing,weaving, bamboo craft, and boat making). Our surveys have indicated that a loss of around INR 2-5 lakhs at current estimates are incurred by displaced households. Shrinkage in the size of the island due to erosion is also leading to internal redistribution of population and/or out-migration of people; and changes in settlement structures leading to establishment of large sized villages. It is becoming difficult to allot land to the displaced with shortage of land within Majuli and displaced people are setting up their temporary houses in and around the embankments and / or moving away from Majuli. During floods, people are using hand rowed boats and in some cases diesel powered boats to move to safer places.

The poorer segment of the population is generally confined to the erosion and flood prone parts of the island that are classified as the most vulnerable. The displaced population sets up houses next to the embankment or next to PWD roads (see photo alongside) due to lack of allocation of appropriate land. During flood people from these houses climb up the embankment next to their houses. They are given an amount of Rs75 lakhs to1 lakh by the district administration to set up houses. These are bamboo houses on stilts.

Photo of bamboo houses on stilts next to the embankment road- These are of people displaced from erosion prone areas

8.2 Livelihood disruption

About 82% of the livelihoods in the villages are at risk due to floods and erosion. Chief amongst them being agriculture. Followed by people who are labourers as they are out of jobs during floods, and people in other profession. The “Others” Category includes, weavers, potters, carpenters, electricians, barbers, masons, trailor drivers and fishermen. Business in Majuli mainly consists of shop owners, rice mill owners and oil mill owners. Though there is a disruption in people commuting to offices, but the salaries of government and private sector officials is secured and therefore they do not suffer loss in income as do the other livelihoods.

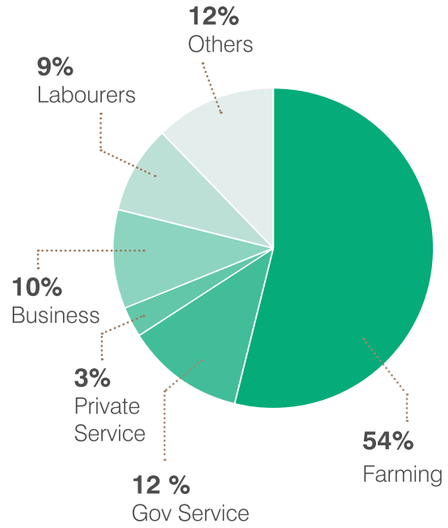


Figure 10 below shows the livelihood pattern that has emerged from our survey.

At least one woman from each family is involved in agriculture. Therefore, participation of women in agriculture activities (including crop management and animal husbandry) is equal to that of men. The survey indicates that the women in Majuli also like men are driving power tillers and trailors for carrying harvest. Household level weaving is carried out by women only in the tribal communities . All villages have reported women in government service.

8.3 Propensity towards Poverty

During the survey it has been reported that families displaced due to erosion have hardly been rehabilitated so they do not get land for agriculture which they have lost due to erosion. Due to paucity of alternate livelihoods the displaced families are pushed towards becoming agriculture labourers. As work is not available during flooding season, abject poverty sets in amongst the displaced families.

Shrinking of the island is associated with increasing poverty and marginalization with falling economic base of the island. Rapid

decrease in the size of the island and annual flooding has not provided adequate time for the affected people to adapt themselves to the changed economic condition, nor does it permit quick diversification of the economy. The net result is increasing poverty and marginalization of a large segment of the population[31].

In flood-prone areas people do not lose the land, they can use it for agriculture after flood waters recede. Further they are compensated for the losses incurred. e.g. loss in crop is compensated for, so is loss in livestock and assistance for damaged housing is provided as well. The flood prone area people also receive relief after floods in terms of medical assistance and provisions.

8.4 Crop and livestock loss

Most households practice subsistence agriculture with around 10-20 percent as marketable surplus. Cultivation is organic except for summer paddy and vegetable cultivation which use urea. Paddy is the main crop in Majuli. Area under Winter Paddy (Sali) is 13,000 ha; Summer (Bodo) Paddy- 4,500 ha; Akam Paddy is 6,000 ha. and Deep water paddy (Bao) is 9,000 Hectares. Marketable paddy surplus in the district is 500 MT. In the absence of Food Corporation of India (FCI) and Assam Agricultural Marketing Board (AAMB) in the district, institutional arrangements for procurement are limited. Local buyers procure paddy and sell to larger markets in Jorhat and Lakhimpur.

Other crops grown in the district are -Pulses and Oilseeds (mustard, Green Gram, Red Gram, Lentils). The production of oils seeds last season was 5.5 metric tons. There are three oil mills in the area. Sugarcane cultivation takes place in Majuli but sugar mills are not present in the district. Currently, sugarcane waste/ bagasse serves as fuel for sugarcane processing and preparation of Jaggery. Potato, lentils, pea, cabbage, Cauliflower, Capsicum are some of the other vegetables grown in Majuli.

Table 11 below presents the sowing and harvesting times of some of the major crops grown in Majuli . This is based on the survey undertaken. Sali rice crop which occupies maximum area under cultivation is under threat as its sowing time and the growth period coincides with the flooding months in Majuli i.e between June to September. Therefore growing Sali without seasonal advance warning on rainfall and likelihood of floods is risky. Bao rice, though sown and grown between March to September, being deep water rice is able to survive even during flooding season. The Ahu rice sown between February to April and harvested between June to August is at high risk again as floods in Majuli seem to strike in June and continue till September at times.

Boro rice is grown in least area as compared to other rice in Majuli (see Table 11). But it is sown, grown and harvested within the most safe climate window available to Majuli from September to April that is free of floods. But

Area inundated in Bongaon area in Majuli due to pre-monsoon showers in early June in 2017

[31] "An Assessment of Redistribution of Population in Majuli Island due to River Bank Erosion," accessed March 22, 2017, https://iussp.org/sites/default/files/event_call_for_papers/iussp13.pdf.

to increase the area under Boro rice, irrigation coverage has to be increased substantially as rainfall is minuscule during this period and according to our survey only 3% of farmers land is irrigated in Majuli (see figure 12). The farmers need to stick to the November to May window for Boro rice to avoid pre-monsoon shower, as pre-monsoon showers tend to happen in early June. For example, by 4th June this year i.e. in 2017, in Bongaon area of Majuli, about 300 ha got inundated destroying the crop that was planted[32]. Further, Boro rice farming is expensive for farmers in general as (a) the seed price of the HYV varieties is high, (b)because farmers have to have pumpsets and fill it with diesel for extracting ground water for irrigation, (c) this rice variety uses urea and is not organically grown as the other varieties

Vegetables, pulses and mustard are all grown in the flood safe months as well when the island does not have floods or erosion i.e. between September to April. Sugarcane grown in comparatively high land areas in Majuli are at Low Risk despite their growing period covering the flood season.

The livestock holding in Majuli constitutes of Cows, Buffaloes and sheep. Some households do rear chicken as well. Livestock loss reported is around 10% to maximum 100% of the total livestock count in the villages. The livestock that is saved is because these move to the embankments and on PWD roads that are on

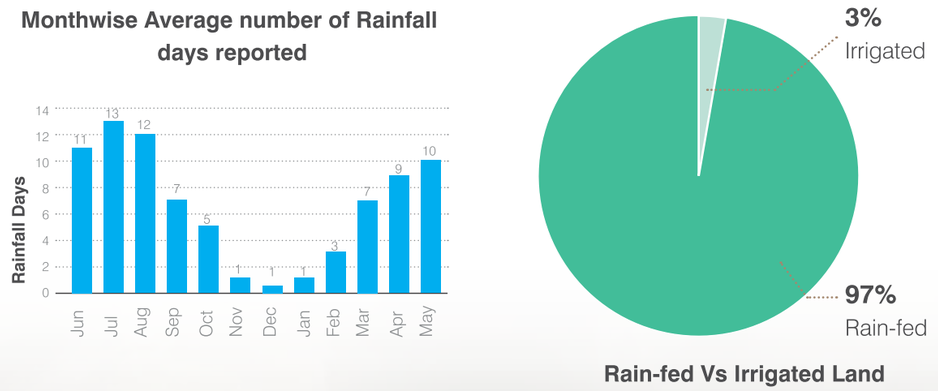


Figure 11: (a) Rainy days across the months as indicated by survey respondents across the 14 Panchayats surveyed and (b) rain-fed vs irrigated area in Majuli

[32] Check Facebook page of district administration, Majuli, dated 4th June, 2017

higher lands. For their survival, during floods livestock is fed on stored grass, paddy straw, and rice husk. The farmer can carry small ruminants by boat or raft to safe places but carrying a group of 4-5 cattle on them becomes difficult. Sufficient early warning can help in easier transport of livestock on high grounds on time.

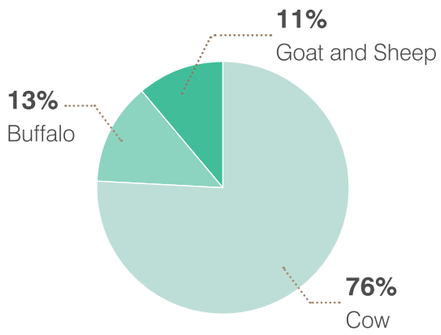


Figure 12: Livestock distribution in the surveyed villages in Majuli

Further our survey has indicated that very few farmers have insurance coverage either for crop loss or livestock loss. Our conversation with the departments, however, indicate that they have started providing insurance packages for crop loss and insurance for cattle as well. But all farmers especially the marginal farmers are not ready to pay the premium. Also the department of Animal husbandry does grant compensations for the losses incurred. According to the agriculture department, in 2015,about INR 19 lakhs were provided as compensation for crop loss.

8.5 Food security

Food security during monsoon is at risk. As majority of rice, the staple food of the inhabitants being sown at the onset of monsoon, is washed away due to floods. Since all areas are not flooded every year, some production remains though. People also tend to store rice as well as pulses in their houses either in (a) granaries on stilts or (b) within their houses in attics that are like false bamboo ceilings just below the roof, but that is not enough to last if the flooding season lengthens and their houses also gets washed away. Further the price of essential items including rice goes up abnormally high (between 30-40% increase in prices is reported). Also it has been reported that the PDS system distributing rice, also includes the cost for transportation from mail land to Majuli. The price is unaffordable for displaced people. The displaced and poverty ridden people therefore are at extremely high risk of becoming food insecure unless they reach the shelters where free food is available.

Also, there is lack of enough storage in terms of commercial storage silos availability in Majuli. As indicated earlier on least flood years Majuli is able to register an excess of 500 MT which can be stored and used for contingency or for sale. At household levels, people do store their produce in their own premises in granaries that are on stilts. But respondents indicate that the flood waters are as deep as 7-8 feet and seep into houses on stilts wetting the rice stored and leading to rotting. Therefore, food security of the island is an issue. New methods of storage and more commercial level silos are required for storing rice in the future and making Majuli food secure.

During floods, fisheries become non-functional as fish also flow away with the flood waters. As a result, nutritional security of the population is affected. Building of pond with tall dykes (1.8 m and above) and surrounding the ponds with nylon/cotton nets can become effective adaptation techniques that can be followed to ensure availability of fish from such pond dykes.

[31] Check Facebook page of district administration, Majuli, dated 4th June, 2017

8.6 Potable Water availability

As of 2016, PHED in Majuli reported that 40 to 55 lpcd of water is supplied to about 10,000 households in Majuli of the total 41,000 households. The rest draw potable water from shallow tube wells. Within our survey area however, only 1% of the respondents have reported availing tap water (public + private taps). 87% Households are availing ground water through tube wells as ground water is abundant and is found within 4 m depth at Majuli[33] (see Figure 13). However, there is a problem of arsenic content in ground water in Majuli which is much above the WHO standards (~0.01 mg/lt). According to Indian standards, a concentration of 0.05 mg/lt, is considered to be normal. Nano plants for removing arsenic are being set up wherever the concentration is >0.05 mg/lt. A proposal for harnessing water from the Brahmaputra has been proposed. Given the arsenic content in water more and more use of surface water should be the norm in future for Majuli.

Therefore, during floods most of the places do not have access to potable water and rely on contaminated water creating a health hazard as a result. Few are collecting rainwater as well but that is generally air pollutant loaded. Water from both the sources are boiled and filtered during floods to avoid diarrhea and jaundice.

8.7 Health and Well Being

Acute diarrhea, respiratory diseases and skin infections are common in Majuli along with symptoms of arsenic contamination. During floods, jaundice, vector borne diseases such as malaria, diarrhea and skin infection cases become rampant. Some of the respondents also have reported snake bites and death due to electrocution during high floods. In 2012 heavy floods, respondents have indicated that about 10 people died of electrocution. It is likely that with warming of the climate incidences of diseases will increase in number and Majuli may face new and emerging diseases as well. Figure14 indicates the distribution pattern of different types of diseases reported by respondent during floods.

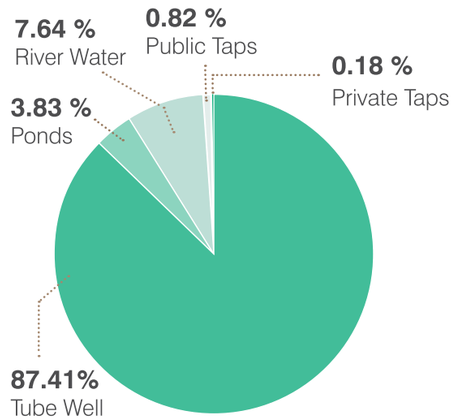


Figure 13: Percentage of households sourcing water from various sources in surveyed area in Majuli

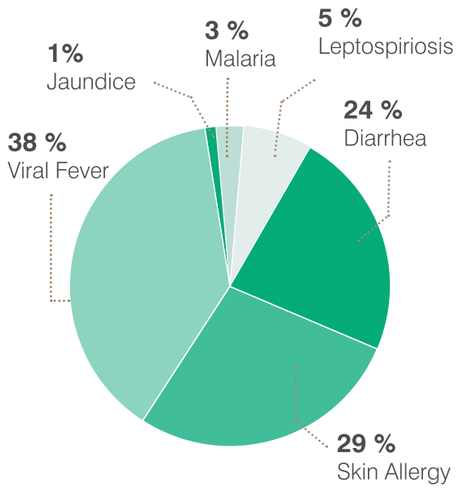


Figure 14: Percentage distribution of various diseases occurring during floods in Majuli

[33] Central Ground Water Board, 2008. Ground Water Information Booklet Jorhat District, Assam. Central Ground Water Board, North Eatern region. Available at: http://cgwb.gov.in/NEW/District_Profile/Assam/JORHAT%20DISTRICT.pdf

8.8 Access to Electricity

In the surveyed area about 83% of Households are electrified and rest are not electrified (Figure 15). During floods the electricity supply becomes erratic as transmission and distribution gets affected. At a stretch, there is disruption in electricity supply for a few hours to many days in some locations. Therefore even the 835 electrified houses are affected by the outages during floods. Majuli currently is supplied by electricity from the main land. People use kerosene lamps and candles during outages in the night time. Though solar lamps have been distributed on the island, but respondents have not mentioned receipt of these, indicating that large scale deployment of solar lamps is necessary for use during electricity outages during floods. Electricity supply has not reached Ahatguri and Dakhin Ahatguri areas in Majuli. Here the inhabitants also use solar lamps and some have rooftop solar facilities. As indicated in the list of development projects,Majuli is investing in renewable energy development,especially solar, to meet future demand and bridge gap areas.

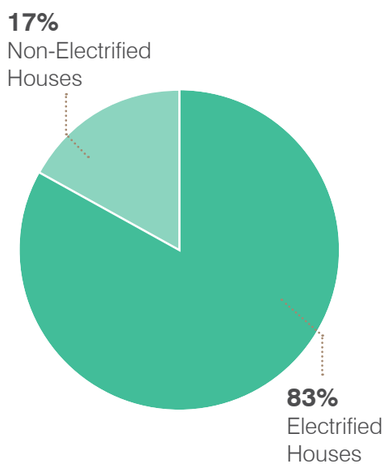


Figure 15: Access to electricity by households in the 14 Gram Panchayats surveyed

8.9 Access to Energy for Cooking

Sixty percent of the surveyed houses use mud/clay stove, 37% of houses use LPG in the surveyed area(Figure 16). In entire Majuli through only 11290 households (28% of total HHs) have LPG connections out of the total 41000 households (as reported by department of Civil Supplies, Majuli). Penetration of electric stoves, biogas and improved stoves is minuscule in the surveyed villages which is also representative of entire Majuli. For cooking, firewood, coal and kerosene is used during this period if LPG is out of stock or connection is not there. Clay or mud stoves used by majority of the households is at risk of getting soaked and washed away during floods as they are placed on floors if the flood waters reach up to the floor level. During such times, people use mud stoves built in oil canisters. Firewood is used in these stoves that is also stored in the attics of the stilt houses.

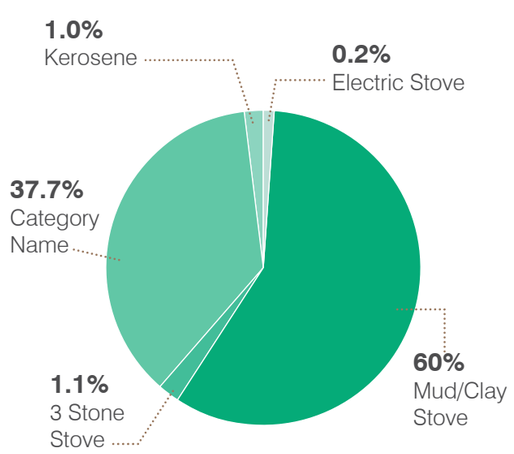


Figure 16:Types of cook stoves being used by the respondents in the 14 Gram Panchayats

8.10 Risk to Infrastructure

Infrastructure impacted (fully damaged or partially damaged) in Majuli due to floods and erosion include roads and houses. Most of the houses in the flood prone areas are on stilts, but have GCI roof (82%) and concrete roofs (14%). See Figure 17.

People report that the village roads turn murky even during low flood events as they are kuttccha roads. The pucca road, mainly the embankment road gets damaged at various points, and also it is washed away due breached embankments. The new infrastructure that will be coming up in Majuli will mostly be bridges, roads, office complex, residences for officials, community halls, auditoriums, schools. These being government assets, are likely to follow flood resilient designs and are not constructed in erosion prone areas.

Strict policies on no-go for habitations cropping up in erosion prone areas need to be formulated and implemented. Currently, the indigenous tribes still live in traditional bamboo houses that are raised up on stilts to let the flood water flow through and below the actual house. These are most effective in low flood years. These traditional housing patterns can be tweaked scientifically with modern techniques introduced to build more resilient concrete houses to reduce risks of housing to floods.

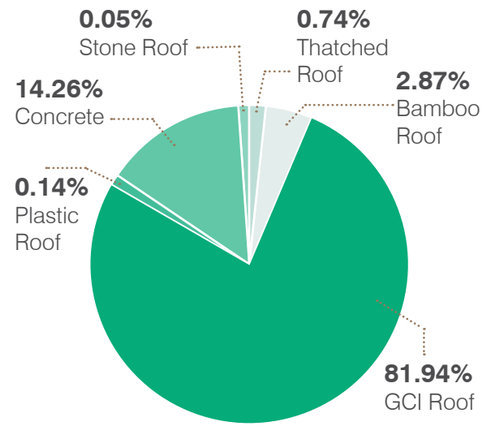


Figure 17: Type of housing in the 14 Gram Panchayats

8.11 Access to Sanitation

Access to toilets in surveyed area is poor as the respondents have indicated that about 73% of the households in their areas do not have access to private and public toilets (See Figure 18). Open defecation is almost the norm in the villages. The PHED is in the process of constructing private toilets for BPL families and also public toilets under the Swatchh Bharat mission, but numbers deployed so far are not enough. Though plans are on to cover all BPL households and create public toilets in prominent public places within the villages. Clearly sanitation is at peril during floods. People are defecating within their houses and creating a very unhealthy environment within the houses as well as in surrounding areas when the flood waters are stagnant. the defecation gets mixed with flood waters polluting the waters further. Innovative sanitation mechanisms need to be in place so that they don't get flooded during flooding events and the waste water is safely carried away and treated.

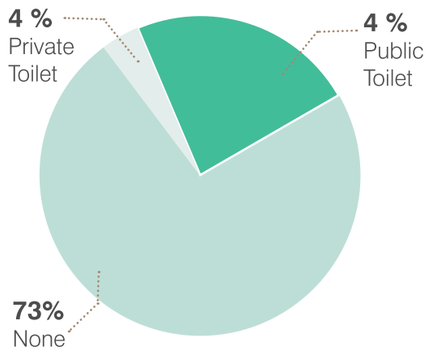


Figure 18: : Access to sanitation to households in surveyed area

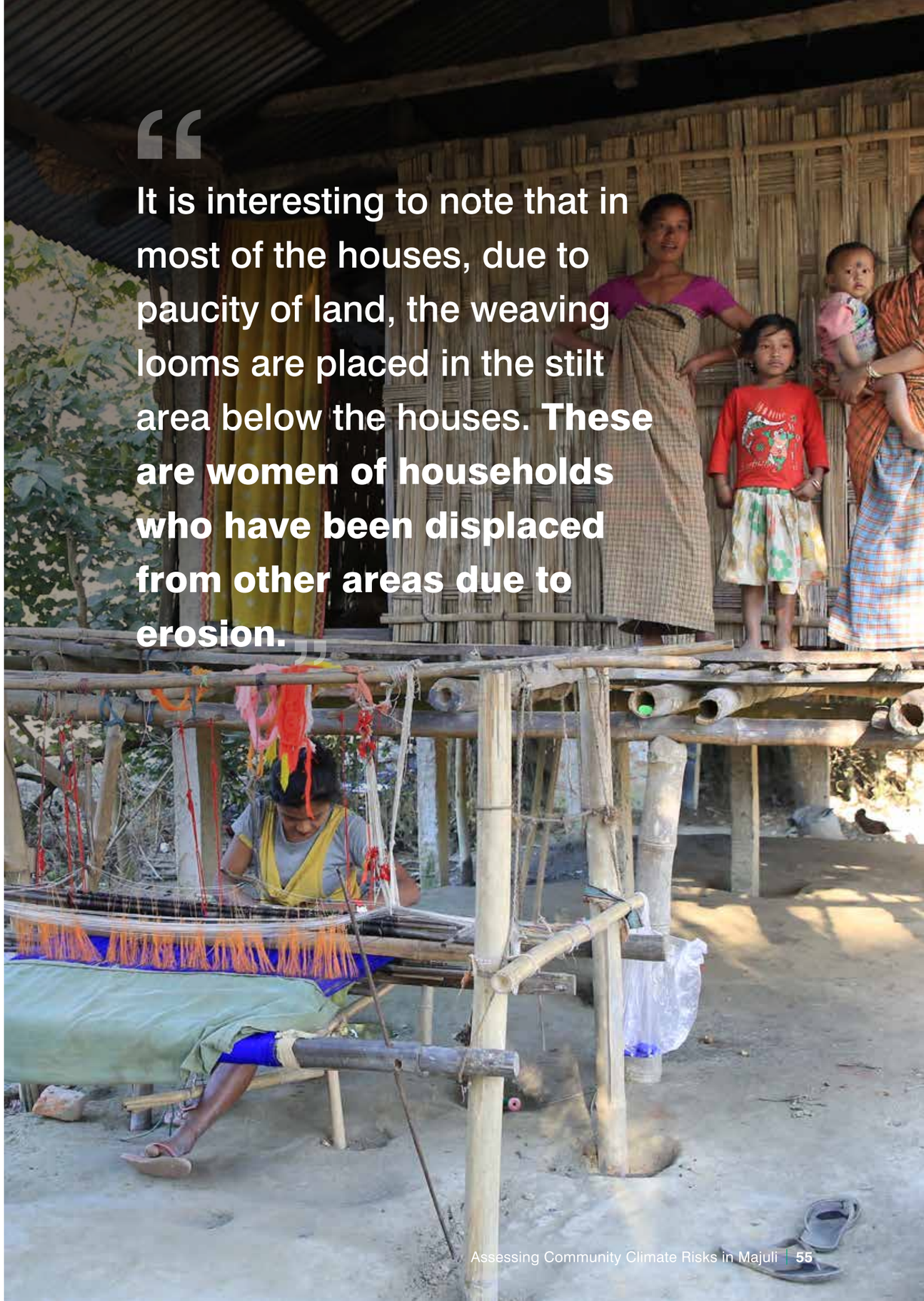
8.12 Gender and Floods

Women, children and elderly tend to be the most disadvantaged during floods and due to loss of their houses and loss of land during erosion. They do not have access to private toilets, neither adequate nutrition.

Nutrition: Children miss school during high floods, and hence also the midday meals that they receive in schools, which may be the only source of nutrition for some during heavy flooding events. The midday meal scheme in schools also accommodates pregnant women of the area and provides them with food but all this is not accessible because of the high floods in certain years.

Livelihoods: It is interesting to note that in most of the houses, due to paucity of land, the weaving looms are placed in the stilt area below the houses. These are women of households who have been displaced from other areas due to erosion. As a result livelihoods based on weaving in such HHs is entirely disrupted during the floods for a period of 2-4 months affecting earnings. The women weave daily for 3-4 hrs after they finish house work and before their children come back from school. They are able to create one set of traditional Mekhla Chadar in 15 days. The price they sell it at is Rs 1500-2000. There are NGOs who buy the weaved material from them. The cost of cotton thread is around Rs 500. As a result in a month they can earn upto Rs 3500. But this is lost during floods.

Women's Health: People have reported that births tend to happen at home, during nights as floating medical services are not available then. So immediate care is not received by women during birth at night time and as a result some deaths at child birth have been reported. However, women are advised to move to high places a few days before birth so that they can receive adequate medical attention in time.



9. Key Institutional Adaptive Capacities Identified in Majuli

9.1 Flood Warning

NESAC (the North Eastern Space Application Centre) in collaboration with ISRO has developed FLEWS. Prime services under this activity include early warning of flood in magnitude (severity), location (revenue circle/ group or cluster of villages) and probable time, High rainfall warning with location and time, post monsoon status of embankments in various flood causing rivers, etc. By the year of 2016, all existing 27 districts and 7 newly created districts of Assam have been taken up by NESAC, taking the total number of major watersheds to 43 covering both Brahmaputra and Barak valley. After the initial pilot phase from 2009 to 2011, the Government of Assam expressed its willingness to fund and operationalise this activity for the first phase from 2012 to 2014 and again the second phase from 2015 to 2017. An average year-to-year alert success score of 75% and an average alert-to-alert lead time of 24 to 36 hours have been maintained during these years. Example of such warning is depicted in Box 2 below, recently issued for Majuli on June 1, 2017.

Such warnings are also issued on television and on mobile phones. Within the survey area, it is reported that on average 57% of the HHs have television and about 39% HHs access to have mobile phones. Though few villages have almost 100% access to these devices. Early warning is provided on the district administration Facebook page. As general public do not have access to Facebook, FM radio with 24 hrs entertainment may be the best option for people to catch up news on flood and erosion warning as the transistors can be carried everywhere and one does not have to be IT savvy. Currently Majuli specific FM radio service is not available. Further for creating and sustaining awareness about dos and don'ts before, during and after floods, the dance drama's of the Satras can convey these messages.

Box 2: Low to moderate flood alert issued for Majuli from FLEWS (Flood Early Warning System) on June 1, 2017

Recent hydro-meteorological analysis reveals a probable low to moderate flood situation as per the following details.

District	Majuli
Revenue circle	Majuli
River	Brahmaputra main
Date and time of issue	1st June, 2017, 18.08 hrs
Validity of alert	12-36 hrs

Facebook page of district administration, Majuli

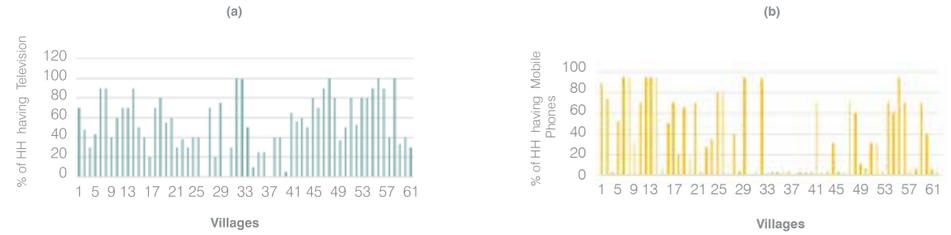


Figure 19: Percentage of houses having access to television and mobile phone

9.2 Education Level and Access to Education

These two together are considered a key parameter that enables a community to better manage pre, during and post disaster situations and for embracing techniques and technologies required to ensure long term climate resilient adaptation. The education institutions operating within Majuli are primary schools, higher secondary schools, colleges and Satras indicating that Satras have a substantial influence on Majuli's education landscape and therefore can make a difference through their own mechanisms. Within surveyed population, 23% of the population is educated only up to class 5 (primary), 49% of the population is educated till class 10 (secondary level) and 28% of the population have graduate degree. Therefore 71% of the population can be considered educated enough to understand the requirements of embracing new techniques and technologies for adapting to continued floods and erosion in Majuli. These can also become centers of higher learning encompassing other streams of education as well.

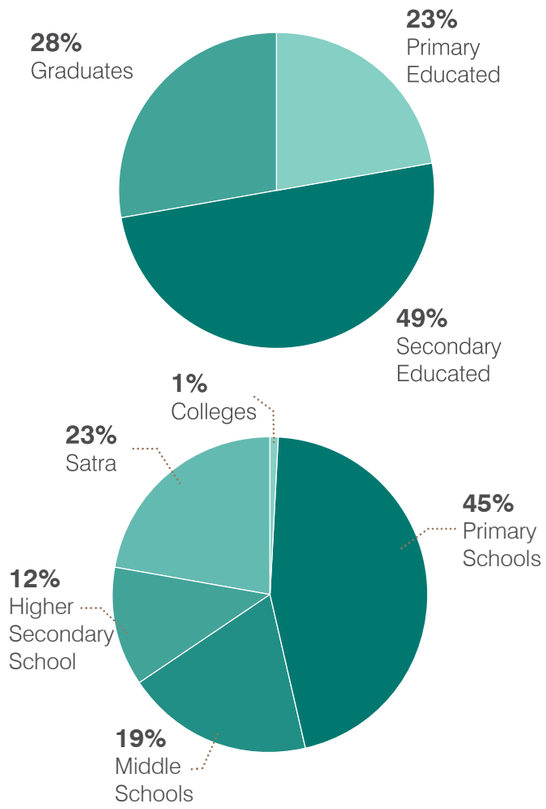


Figure 20: Education level and access to education

Health centers: Our survey reveal that there is poor access to health facilities. Out of the 14 Gram Panchayats visited, the respondent indicated that there are only 2 government hospitals, 2 primary health centers and 2

Medical vans deployed for remote areas
Photo courtesy: District Administration Majuli

community health centers. The government has started 3 mobile clinics equipped with sophisticated Laboratory Service in Majuli. That will operate in remote villages in the district. The portable clinics will provide completely free health services to people living in remote areas of Majuli, areas which are far-off from the health centres, areas with poor transport connectivity. Each MMU has a Doctor, a Staff Nurse, a Laboratory Technician, an Opthalmic Technician & a Pharmacist. For the first time, NHM introduces this kind of highly equipped MMU Van in Assam to provide sophisticated Laboratory service to the people living in remote areas at free of cost.

In adverse conditions at night, when the weather is bad, the mobile vans cannot reach the patients, and a boat ride for the patient can also be risky, in such times, the Island communities needs more skilled attendants, who can rush in quickly as they are within the villages itself.

9.3 Community Institutions

Community institutions such as village development committees, Panchayats, Joint liability groups, Self Help Groups (SHGs), Mahila Mandal, Watershed committees, VFC (Village Forest Committee)/JFMC (Joint Forest Management Committee) /EDC (Ecological Development Committee), and the Panchayat are some of the institutions that meet regularly in the villages have been identified. The strength of the institutions is evaluated on the basis of the number of meetings that is undertaken each year. As a result, SHGs, Youth Groups and Village development committees evolve as the strongest institutions. The SHGs are involved supporting women, and other entrepreneurs for setting up small businesses through micro finance mechanisms.

However, the banking system does not seem to exists in these villages as no mention has been made of existence of government or rural banks. Though online data suggests that Majuli atleast has 5 branches of Government banks in Garmur, Kamalabari and Bongaon. These include, SBI, UBI, UCO, Assam GraminViikash Bank. But they are located only in these places. The Bank can come to the people by sending their agents. Then issues such as lack of awareness and complex processes of accessing banking loans might be removed.

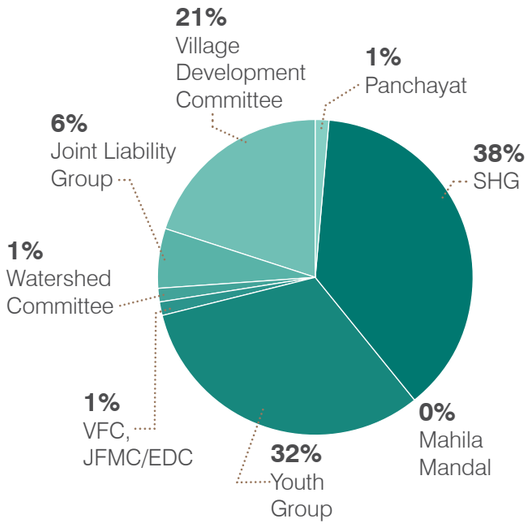


Figure 21: Type and strength of the community institutions

9.4 Awareness Campaigns on Preparedness for Disasters

Regular awareness campaigns are being held in Majuli as indicated in a latest picture below published in the Facebook page of the district administration which mentions convening such a campaign in Brahmaputra Dyke at

Nikinikhuwa, Bongaon, and Kandhulimari. The Water Resources Department carries out these programmes. However, our survey indicates no such campaign being carried out in the interiors of Majuli.

9.5 Majuli Disaster Management Plan

There exists a Majuli disaster management plan that is focused on preparedness, action during hazard, reconstruction phase. As a part of this plan the district administration has identified a Sub divisional relief committee, an early warning team and also a search and rescue team. Further it has first aid and trauma counseling team to provide immediate attention to the impacted. Additionally there is a sanitary and drinking water team which supervises the preparedness before the flood season. A resource inventory, capacity analysis and vulnerability mapping has been carried out to identify the flood and erosion prone areas (see section 5). Given the preparedness,

Mobile water treatment plant of 2000 litres capacity stationed in Majuli. There is a also water testing quality lab as well.

further strengthening of the same required as Majuli continues to reel under the impacts of floods and erosion.

10. Recommendations

Addressing Displacement

The Brahmaputra Board has spent thousands of crores on constructing and retrofitting dykes in Majuli along with setting up RCC porcupines and spurs for bank protection along erosion and flood prone areas. However these are being breached continuously and Majuli faces inundation every year starting from June. Extent of flooding being varied annually. In these circumstances, it is suggested to undertake detailed feasibility study to integrate the bioengineering methods along with civil engineering approaches to stabilise the river banks and to prevent bank erosion and breaching of the dykes.

10.1 Improving Early Warning Communication and Awareness

It is proposed to have an FM radio station in Majuli to broadcast the warnings. The station in addition to broadcasting entertainment can broad cast on a regular basis:

- Flood Early warnings released by the Majuli Government
- Seasonal rainfall predictions for farmers to prepare them for the cropping season
- Advance 15 days, 7 days , 72 hrs, 48 hrs and 24 hrs forecast of rainfall for preparing farmers for sowing and harvesting.
- Further it is proposed to use the the Bhaona's (drama) as vehicles of spreading the message of conservation in Majuli along with guidelines for preparing for floods, what to do and expect during floods and how people can be a part of the reconstruction phase after the floods. Regular staging of Bhaona's that have the awareness campaigns integrated can go a long way as Satras are intertwined in the cultural landscape of Majuli.

Bhaona a medium of communication being enacted in Kamalabari Sattra

10.2 Ensuring Food Security During Floods

Cultivation of rice is taken up in the district almost throughout the year and can be grouped into three seasons viz., winter season with main sali rice, autumn (regular ahu) and summer season (Early Ahu and Boro). Besides there is a Bao crop which is deep water rice and sown during ahu season in areas where transplanting during main sali crop is not possible due to high standing water, and harvested along with sali when water recedes. The transplanted sali rice is the main crop and accounts for about 76 to 77% of total paddy area in the district .However this is the most risk prone rice in Majuli due to recurrent floods.

- Promote Bao rice or floating rice and connect it with fair price certification to encourage farmers to grow rice during the rainy season with market connect. Also include promotion of farmer producer organisations that can aggregate local produce and supply to bigger markets or end users.
- Promote cultivation of Bororice during the dry season from November to May. Ground water being abundant, it can be used for irrigation extensively during this period. Farmers are using ground water for irrigation, There are currently 5000 pumps in Majuli using diesel for pumping ground water for irrigation. They are polluting the environment and can be replaced by solar pump sets. This is happening but slowly. Attractive financing mechanisms for the farmers will have to be devised for them to embrace solar pumps. Further to avoid arsenic contamination in rice grown with ground water having high arsenic content, the water pumped from the ground can be stored first in open un-permeable ponds to aerate it and then through channels it can go to the fields.
- Further, create community ponds with high dykes that will not allow water to seep in during floods and as a result it will be enable fisheries to sustain even during floods. Such examples are available else where in Assam itself.
- For cattle, it is proposed that cow shelters may be built on high ground within the villages so as to house them during the floods. Also, it is proposed that tubular silages be created at HH level or community level for the cattle to sustain on during floods. For this extensive training to the farmers on preparation of silages have to be carried out.

10.3 Ensuring Sustainable Livelihoods and Steady Income

It is necessary to have diversified livelihoods within families so that enough earnings are there to sustain through the floods. The people are involved in pottery in some villages, women in weaving in tribal villages and mask making in others. This is in addition to agriculture that people pursue. Livelihoods entwined with the way of life in Majuli that can be further promoted can be:

- A sustainable and responsible ecotourism industry
- Small power looms for women located at nearby community centre with new designs every year and established value chains of their products can ensure sustained monthly income
- Off Farm producer organisations can help take locally produced artifacts to the markets in other towns, cities and industries to ensure sustainability over the long run.
- Strengthen the bamboo industry to produce artifacts for assured markets. This can e further strengthened by encouraging bamboo plantations with financial incentives for survival. The Bamboo Board of Assam needs to be consulted for strengthening this industry further in Majuli.
- Indigenous boats of Majuli may be marketed as a Majuli brand . The Majuli boat makers can cater to their demand and earn enough to sustain themselves through out the year.
- Similarly, pottery and mask making has to go designer as well. Experts from premier design institutes can interact with the artisans to produce these products and sell them in faraway markets to get premium price as a Majuli product.

10.4 Ensuring Water Security

Piped water is the safest water, which is available only to a small percentage of HHs in Majuli. Currently only 10,000 HHs receive piped water. The rest draw water from the ground at shallow depths that has arsenic which can be removed through aeration. It has been proposed in Majuli to harvest the river water which is arsenic free and supply it to the households. In our view as water in Brahmaputra is abundant, it should be harnessed to ensure water security in the island.

In the short term, aerated ground water in tankers can be supplied which is also cleaned of other pollutants by a 2000 litres per hour water purifier that Majuli already has (see photograph in section 9.5). But during heavy floods water can be deployed only through

boats and may be airdropped. During low flood situations tankers can reach communities and pipes from the tanker can be used to fill up the overhead tanks on peoples homes. What is needed is a community involvement to ensure water availability and distribution during flooding period.

10.5 Ensuring Health and Well Being During Floods

Though mobile vans have been pressed in recently which will go into remote areas, the problem in Majuli is that trained and specialised doctors do not tend to remain in Majuli as its hazard prone and life is difficult. As a result the standard doctor patient ratio that is desirable is in an abysmal condition. This is the situation in all places that are not cities in India. The following is suggested to improve the situation.

- Women and men from communities can be trained as Asha's to support prevention, detection and treatment of diseases. They can be government staff or a private agency or an NGO can start this service with required permissions from concerned authorities. Women Asha's will support prenatal and post natal care along with supporting child birth. They can be given licenses to operate, which will be revoked if found not delivering services according to norms set for them. They can have direct connect through telemedicine with specialised doctors in remote locations who can advise them on critical cases- which in most cases would be transfer to main land. A doctor can visit the communities on a weekly basis to monitor and review their advisory to patients. The Asha's can be regularly trained to help them to retain knowledge and learn new advances in techniques for managing health in communities including during disasters.
- Further airlift facilities should be provided to Majuli for air lifting critically ill patients. This emergency service needs to be pressed into service on an urgent basis in Majuli. Helicopters while in the flying mode can airlift patients without landing on firm land during floods.
- Awareness campaign on health safe techniques need to be held more in all parts of Majuli and on a regular basis especially before the onset of monsoon.
- District administration needs to ensure distribution of water purifying kits for all HHs before the floods to ensure health and control of water borne diseases.
- Improved chulhas may be deployed to get over the impacts of pollutants affecting people emitted due to inefficient fuel wood in traditional chulhas.

10.6 Addressing Energy Security During Floods

Solar roof tops, community solar mini or micro grids can be deployed in all the villages in Majuli to bridge the gap towards accessing the same.. Solar micro grids are already a reality in Majuli as they are being set up by the government in communities and within Satras to support micro enterprises and domestic energy needs. Solar roof tops on households have been set up in villages where electricity has not reached such as Ahatguri. Solar roof tops are also being set up by AEDA in one of the colleges in Majuli. All these would however require batteries, provisions for which need to be made. Government incentives are now operational to make solar based energy generation a reality as a part of the National Solar Mission.

During floods, it is essential to make available Solar torches and solar lamps. Therefore schemes need to be formulated to procure, and incentivise the buying of these at reasonable prices.

Additionally, possibility of setting up energy plantations on community land can be explored to address the fuelwood requirement of the HHs as supply of CNG cylinders may not be adequate during floods. The energy plantations can be sustainably harvested and managed by the VFCs and fuelwood stored in houses

Also chulhas which are set up on the floors of the houses may be elevated to ensure sustained cooking for the HHs even during floods. Propagation of improved chulhas at waist height is suggested.

10.7 Ensuring Infrastructure Security

The villagers look forward to accessing Pradhanmantri Awaas Yojana funds to construct permanent residences. Some areas in Majuli are accessing it already but needs to spread in other areas as well but they should be allowed only to be built in flood and erosion safe areas and following norms that can make such housing flood resilient.

The administration is creating village roads using small concrete blocks/tiles. The strength of these roads have yet to be tested. And all roads in the villages have not been paved, which needs to happen very fast.

Additionally, lighting of the roads is also a major issue that needs to be addressed so as to ensure safe passage. At the moment street lighting is minimal. Street lights can have a hybrid model for lighting. They can be powered by community grids (micro or mini) in addition to being powered by grid electricity. So that either of them can work when the other is off.

Box 3: Example of Flood Resilient Housing

The Pradhan Mantri Awas Yojana funds can be used for making locally-abundant bamboo, natural thatching to make buildings inspired by traditional building techniques in Majuli.

The design of the houses can be further secured together using a system of anchors and ties. The unit can be structurally anchored with welded steel piles that still allows the structure to withstand the force of flood water and up and down movement to dissipate energy. There's can be a rainwater harvesting system integrated to ensure clean potable water during floods with a one-way valve that starts up backup support systems when floods do arrive.

Source: https://www.treehugger.com/green-architecture/affordable-disaster-resistant-bamboo-housing-floats-in-flood-hp-architects.html

Photo Credit: Vertiver

11. Proposed next Steps

To take this assessment further, it is proposed that each of the recommendations be run through the district administration for their inputs and acceptance. Further the set of recommendation's accepted, full-fledged project design documents be formulated for funding.

If necessary provide policy support for integrating the suggestions in the ongoing programs of the government such as building climate resilient indigenous houses with funds from Pradahan Mantri Awas Yojana.

The steps towards the same is depicted diagrammatically below

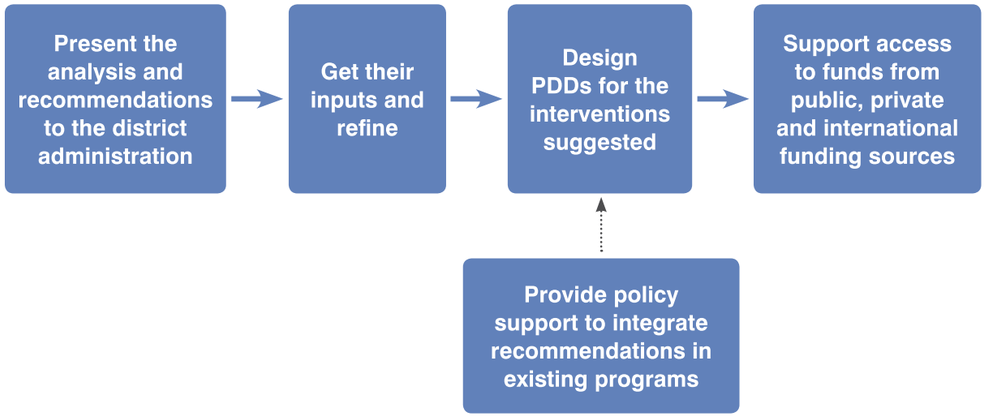


Figure 22: Next steps.

Annexure 1

Questionnaire used for rapid risk assessment of Majuli due to floods and erosion

Village Amenities

a) Health Facilities: Government Hospital: ☐ Private Clinic: ☐ Health Care Centre ☐

b) Educational Institutions: Primary/Middle/Higher Secondary/College/PG

c) Drinking Water (State number of families accessing these sources)

Public taps		Tube Well	
Water Tank		Ponds	
Private Taps		Spring water	
Others			

d) Sanitation Facilities (No. of Families having these facilities)

Private toilets		Public Toilet		None	

e) Access to Electricity (No. of Families)

1)Electrified Houses		2)Non-Electrified Houses			
4)SPV		5)How Many are working		6)Are you using irrigation pumps	Yes No
If 6 is Yes	Diesel Operated		Electricity Operated		
Reasons for SPV non-functional:					

Electricity availability

Time of Day/ Season	Summer (March-June)	Monsoon (July-September)	Autumn (October-November)	Winter (December -February)	Rank the timing by usefulness **
0400-0700					
0700-1200					
1200-1700					
1700-2200					
2200-0400					

**** Please give score to the time-period when the electricity availability would be most useful (between 1-5, 5 being most useful and 1 being least)**

When do you experience disruption in electricity services?	Regular ☐ Sporadic ☐
If regular,	How many hours per day?
	What time of the day?
If occasionally,	What specific time of the year (months)?
	Number of days electricity is unavailable

Access to communication

% of HHs owning television	
% of HHs having smart phones	
% of HHs having non-smart phones	

Road Accessibility to village: (YES/ NO, if Yes Kuccha/Pucca)_____

Are the following institutions present in your area?			
	Y/N	If yes, frequency of meetings (no/year)?	Remarks
Panchayats			
SHGs			
Mahila Mandal			
Youth groups			
VFC/JFMC/EDC			

Are the following institutions present in your area?			
	Y/N	**If yes, frequency of meetings (no/year)?**	**Remarks**
Watershed committee			
Cooperative Banks			
Private Banks			
Joint Liability Group			
Others (Please specify)			

Land Use Pattern

Total Area Land (specify acres/hectares/Biga)		
	Area (Biga)	
Land Type	**Regular**	**Encroached**
Irrigated Land		
Rain fed Land		
Grazing land		
Forest Land		
JFMC/EDC Land		
Deep water Land		
Others		
Total Land		

Crop and Plantation details			
Crop or Plantation	**Area (Ac/Hec/Biga)**	**Organic (Ac/Hec/Biga)**	**Inorganic (Ac/Hec/Biga)**
Mechanism to address pests and insects in the AG fields			

Crop	Area (Bigha)	Yield/ Bigha (In quintal)	Sowing (S) and harvesting time (H) (Put a tick in the appropriate cells)											
			Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average no. of rainy days per month														

Crop Residue Use

Crop Residue name	Availability	Common usage in village	Surplus available	Price of residue if sold

Livestock population by type

Livestock population	Native		Cross bred	
	Number	**Dung Availability**	**Number**	**Dung Availability**
Cow				
Buffalo				
Ox, Bulls				
Sheep and goat		NA		NA
Horses		NA		NA

Livestock population	Native		Cross bred	
	Number	Dung Availability	Number	Dung Availability
Pig		NA		NA
Others		NA		NA

Cooking Devices in the village

Device Type	Number of families
Mud /Clay/cement stove	
3 Stone stove	
LPG Stove	
Biogas stove	
Improved cook stove	
Kerosene stove	
Electric stove	
Others	

For what purpose fuel wood is used

Events	Number of Events	Quantity/ event
Religious Activities		
Marriages		
Deaths		

What are the alternatives preferred for			
Cooking	**Heating**		
Is any schemes (Govt. or private) running in the village for alternative source of energy/fuel wood			
Any community or village level initiative taken to provide alternative energy solutions			

Small scale industry in village

A: Diesel based

S. No.	Device	Fuel used	Quantity of fuel used/hour of operation	Cost of fuel

S. No.	Device	Fuel used	Quantity of fuel used/hour of operation	Cost of fuel

B: Electricity based

Sl. No.	Device	No. of devices	Device rating kW	Connected load kW	Operation hours per day	Operation days per year	Cost of electricity (Rs./ month)

Climate Risk		
Do you have floods in your area?	Yes ☐	No ☐
If yes, risks due to floods		
Do floods occur every year in your area?	Yes ☐	No ☐
How many months your area is flooded and which months		
How many HHs have to shift to safer areas (%)?		
Over the years are you going to higher and higher heights during floods or the stilts of your house getting longer?		
During floods are you homebound or you travel by boat?		
What kind of boats do you use- diesel driven or hand rowed?		
Ensuring Food Security		
What food do you survive on during floods?		
Where do you get it?		
Do you store grains to ride over the flooded days?		
What all food items do you store and how do you store?		
Do you have access to Public Distribution System (PDS)?		
Electricity supply		
What happens to electric supply? Is it available if so for how many hours?		
If not then how is your home lighted during floods?		
Do you have solar powered lanterns?		

Do you have LPG if not then what fuel do you use for cooking during floods?		
Where do you get the fuel for cooking (kerosene/ firewood)?		
Water		
Where do you get drinking water from during the floods?	Supplied by the government ☐ Get it on our own ☐	
If you get water on your own- what is the source?		
If the water is not clean, then how do you purify it?		
Health		
Is there any additional sickness in the family during floods? If so what is it?	**Disease**	**Number of People affected**
	Malaria,	
	Diarrhoea,	
	Skin allergies and fungal infection	
	Jaundice	
	Leptospirosis	
	Other	
Agriculture		
How much of the crop sown is lost during floods?		
Do you have crop insurance?		
Where do cattle/buffalo stay during floods		
How many cattle on an average die during floods		
What feed do you give the livestock during floods?		
Do you have cattle insurance?		

Other Information

Annexure 2

List of Gram villages surveyed

SL NO	Block	Name of Gram Panchayat	Name of village	Latitude	Longitude
1	MAJULI DEV. BLOCK	BONGAON	MUDOICHUK	26°56'56"N	94°17'10"E
2			1 NO KARHALGAON	26°56'8"N	94°17'18"E
3		DAKHIN KAMALABARI	JUGUNIDHARI GAON	26°56'20.1"N	94°07'24.2"E
4			BHEKULIMARI GAON.	26°56'46.8"N	94°09'56.2"E
5			BORTANI GAON.	26°56'20.1"N	94°07'24.2"E
6			UPER KATONI GAON	26°56'46.8"N	94°07'24.2"E
7			NAM KATONI GAON	26°55'52"N	94°09'36"E
8			BORITIKA GAON	26°57'00"N	94°8'53"E
9		DAKHINPAT	DAKHINPAT KUMARGAON	26°55'9"N	94°14'58"E
10			DKHINPAT KALITAGAON	27°55'8"N	94°16'13"E
11			NAWSHALI GAON	26°55'21"N	94°16'26"E
12			DAKHINPAT KOIBATTAGAON	26°54'42"N	94°16'33"E
13		POKAJORA	KAKOTIBARI GAON	26°58'38"N	94°12'5"E
14			DEUDIATI GAON	26°57'30"N	94°11'58"E
15			JALUK BARI GAON	No input	No input
16			BARUAH BARI GAON	26°58'37"N	94°11'43"E
17			NATUN DEUDIATI GAON	26°58'20"N	94°12'2"E
18		KAMALABARI	HUKUNAMUKH GAON		
19			BENGENATI KOIBATTA GAON.	26°56'49"N	94°11'55"E
20			URIAMPORA GAON	27°57'45"N	94°11'26"E
21			ALI CHIGA GAON	26°58'36.9"N	94°11'49.55"E
22			KERELA GAON	26°57'45.7"N	94°09'01.5"E
23			BEZ GAON.	26°57'11"N	94°12'31"E
24			BURHA KALITA GAON	26°57'2"N	94°13'21"E
25			BARABARI GAON	26°57'51.7"N	94°08'45.5"E
26			POHARDIA GAON	26°56'09.8"N	94°11'01.6"E
27		RAWANAPER	PERABHARI (MODEL)	27°01'43"N	94°17'18"E
28			THAKURBARI GAON	26°58'14"N	94°15'26"E

SL NO	Block	Name of Gram Panchayat	Name of village	Latitude	Longitude
29			TATAYA GAON	26°56'52"N	94°14'49"E
30			CHARINGAATI GAON	26°57'28"N	94°15'20"E
31			POTIAGAON	26°56'33"N	94°13'42"E
32			KAMARGAON	26°56'30"N	94°14'21"E
33		AHATAGURI	SARUPHAKUA GAON	26°48'19"N	94°54'33"E
34			BORPHAKUA GAON	26°21'18"N	94°28'23"E
35			NOMATI GAON	26°48'26"N	93°59'53"E
36			RAYATI GAON	26°8'3"N	94°18'0"E
37		D. AHATAGURI	ROWMORA GAON	26°47'38"N	93°59'24"E
38			UJIRATI GAON	26°47'24"N	93°59'9"E
39			GHURIA GAON	26°45'27"N	93°55'18"E
40		SRI LUHIT	GUWAL GAON.	26°56'21"N	94°4'13"E
41			KARGIL GAON	27°01'43"N	94°19'05"E
42			BALICHAPORI GAON	26°57'46"N	94°09'43"E
43			BIRINABARI GAON	26°55'41"N	94°03'52"E
44		GARAMUR	KHANACHUK GAON	26°58'39.7"N	94°09'26.2"E
45			SANTIPUR GAON.	26°58'43"N	94°10'3"E
46			GOPALPUR GAON.	26°58'0.2"N	94°09'33.4"E
47			GUBINPUR GAON.	26°58'13.5"N	94°08'25"E
48	UJONI MAJULI DEV. BLOCK	SRIRAM	MILONPUR GAON.	27°02'8"N	94°18'42"E
49			GOSHAIBARI GAON.	27°02'2"N	94°18'14"E
50			SILIKHAGURI GAON.	27°01'43"N	94°19'05"E
51			TAKOUBARI	27°2'41"N	94°19'8"E
52			MUDOIBIL GAON	27°3'41"N	94°19'25"E
53		JENGRAI	MERBIL GAON	27°01'21"N	94°18'58"E
54			BHAKATIDUWAR GAON	27°02'19"N	94°20'16"E
55		RANGACHAHI	RANGACHAHI GAON	27°01'5"N	94°15'12"E
56			POHUMORA GAON.	26°59'12"N	94°15'49"E
57		RATANPUR GAON PANCHAYT	KATHAMIA GAON.	27°02'7"N	94°20'54"E
58			RATANPUR GAON.	27°00'46"N	94°20'38"E
59			LAHAN GAON	27°00'33"N	94°28'44"E

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