Biodiversity and Ecosystem-Based Climate Change Adaptation for Enhancing the Climate Resilience of Coastal Vulnerable Communities in India

BACKGROUND:

Climate change is increasingly becoming a major challenge for various communities across the globe and coastal regions are one of the most affect regions on the planet due to sea-level rise, coastal erosion, cyclones and flooding (Amaratunga, 2022). The dynamic nature of the coastal areas exposes them to various extremities, especially the low-lying areas which are exposed to geomorphologic and oceanographic changes (Cowell et al., 2006). Coastal areas are home to about 40% of the global population, living with 100 km of the coast which are exposed to climate related extreme events (Small & Nicholls, 2003). The National Cyclone Risk Mitigation Project estimates that on average about 370 million people in India are exposed to cyclone annually (NCRMP, 2019). Besides cyclones, India's coastal regions are exposed to storm surges, associated inundation and salinity ingress.

The geographical location and the monsoon wind patterns exposes India to climate change vulnerability. As per Climate Risk Index released in 2018, India is the 5th most vulnerable country due to changing climate (Eckstein et al., 2016). The impact of climate change has major implication for India's agriculture, economy, health and well-being but most importantly the coastal ecosystems and the coastal communities. Such coastal communities are often engaged in activities which are related to fishing or marine resources. There are 36 million fishermen in India whose livelihood depend on such sensitive ecosystems. There are various parameters that constitute a healthy and resilient society, local economy is one such parameter which experiences the highest impact of climate change (Koya et al., 2017). The same study also highlights that social and environmental components of the society are highly affected by climate change which is mainly due to low adaptive capacity of the local communities, lack of awareness, preparedness and availability of mitigative options.

Addressing climate change vulnerability and building climate change resilience to create a sustainable habitat is the major goal of Aga Khan Agency for Habitat (AKAH) India. AKAH has been actively working towards building climate change resilience in Gujarat, Maharashtra and Telangana through various action based research projects. This paper entails the learnings from one of such ecosystem based adaptation project carried out in Porbandar district located in the Shaurashtra region of Gujarat State to accelerate the understanding of coastal vulnerability from India's perspective and develop replicable models for ecosystem based climate change adaptation interventions which can be replicated across the nation's coastline.

The study focused on selected 10 highly vulnerable villages in Porbandar district. The survey size was >1,400 households which is about 10% of total households. This research aligns well with the theme of 'Alternative, nature-based solutions for sustainability challenges (including perspectives from indigenous people)'. The study focused on developing an Ecosystem-based Approach for climate-resilience, building upon the rudimentary and small-scale indigenous practices for physical protection of life and infrastructure; enhanced water availability; improved soil quality –all through nature-based solutions.

RATIONALE OF THE STUDY:

As per the report published by Council on Energy, Environment and Water (CEEW), many districts in the Saurashtra region like Porbandar, Junagadh, Gir-Somnath, and Amreli are highly exposed to climate change induced extreme events like cyclones and storm surges (Mohanty, 2020). Porbandar, a district in Saurashtra region, is highly prone to frequent storm surges, flooding and extreme-weather events. Climate-change is expected to increase variability of rainfall patterns along the Gujarat coastal plain, with more intense rainfall events causing more frequent flooding and reduced groundwater infiltration, and longer dry spells affecting planting seasons. Coastal villages within 100m of the high-tide line are at risk of climate-change impacts (Prasad & Raj Singh, 2022).

Western India's Porbandar coast is known to be particularly vulnerable to the looming threat of Climate Change. These low-lying coastal belts, known locally as 'Gheds,' flood with freshwater and swell

during the monsoons and interconnect with gushing rivers to form biodiverse “mega-wetland” areas, spread over hundreds of square kilometres in some places. The Gheds of Porbandar are a special, diverse biotope and home to lakhs of birds mammals, reptiles and aquatic life. On some parts of the seafront, they coexist with coastal mangrove patches, which in some key locations, check the flow of saline tidal water into the coastline, between the saline seafront and freshwater bodies, and provide a spawning zone and habitat for fish and birds. Unlike the vegetation in the Gheds, these perennial mangroves continue to exist year round, protecting the shore from storms and checking erosion.

After the monsoons, these vast Gheds dry up, what remains is dry land, with a topping of fine sand that was brought in by the sea during the monsoons. This sand slows the flow of rivers towards the sea, in the process spreading the water across the entire Ghed region, where it remains mostly sedentary for around 2-3 months, before it finally dries up completely.

The farmers of the Porbandar Coast have adapted remarkably well to the rhythms of their terrain, developing techniques that take advantage of the Porbandar Coast’s fungible coastline, by planting crops on the wet soil once the waters have retreated from the Gheds. (peanut, Gram, cotton, pulses and vegetables). When the Gheds flood again during the monsoon, they shift to planting rainfed crops on other sites. These farmers have been highly successful using their local traditional ecological knowledge because they have developed a way of life according to their unique environment. Likewise, artisanal fishing villages, taking advantage of the marine biodiversity, have also evolved close to the coast; they they are knowledgeable about the tides and seasons, and brave choppy seas in small boats daily during the fishing season. Today these fishermen export some of their catch, which supports the local economy.

However, not all is well in paradise. The high dependence of these local communities on coastal resources for livelihoods makes them particularly vulnerable to climate change-induced impacts, which are disturbing the delicate and traditional balance of life between the human and natural world. Rising sea levels have resulted in extra silt being deposited into the lowlands, and so the duration for which the waters remain in the Gheds before drying up has fallen from 6 months per year in the distant past, to about 2-3 months currently. This affects the local biodiversity and reduces the amount of water available for irrigation.

Rising sea levels also cause the intrusion of saline seawater into the soil, which impacts agricultural productivity and reduces the availability of safe drinking water. Fish catch too has been steadily dwindling on account of the changes in temperature, waterbodies as well as coastal flora.

In line with global warming-related trends, unpredictable extreme weather phenomena, storm surges, altered rainfall patterns and fundamental weather pattern changes have entered the mix, which can result in arbitrary flooding spreading into new places, especially since increased silt deposits, combined with rising sea levels can displace floodwater in unpredictable ways into human settlements and farmland.

While risks of crop damage, reduced agricultural productivity, dwindling fish stock and the resulting economic losses form one end of the spectrum, on the other end more serious disaster possibilities loom, and entire homes, farms and villages could get submerged. According to recent studies, the coastal communities of Porbandar face higher risks of damage to infrastructure, livelihoods and property, displacement and economic losses due to frequent cyclones and storm surges.

On account of these hazards, fishing communities like those at the Madhavpur fishing village are currently required by government order to vacate their villages during the monsoon season, a period when the entire village temporarily is shifted inland to (Jam Salaya, Dwarka, Okha, Bet Dwarka) for safety. Once the monsoon is over, the entire community shifts back to their original coastal location.

From a pragmatic point of view, while all these risks are immediate, the causes of climate change are global, and show few signs of reversal anytime soon. What is within reach locally, however, is adaptation and building resilience to these risks through afforestation, and recently have been some developments on this front. In November As a pilot project, the Aga Khan Association for Habitat India (AKAH India), in collaboration with the local communities and their women’s self-help groups, planted close to 25,000 mangroves (*Avicennia marina*) on the coastline at Tukda Gosa, on the Porbandar Coast, as an ecosystem-based intervention, to mitigate the area’s coastal climate-related risks, and this was

followed a few months later by another plantation of 80,000 mangroves along the coast of Miyani, another vulnerable village. According to AKAH India's field surveys, at least another 20-hectare area on the Porbandar coast is suitable for mangrove plantation and could benefit from it.

The rationale is that farming and fishing communities here already depend directly and indirectly on the ecosystem services provided by Porbandar's important mangroves, and increasing their spread could help the local economy in communities that depend on natural resources, while offering a protective buffer against climate threats. Although Mangroves currently occupy a small area of the total land on the Porbandar coast, they offer a range of ecosystem services such as protecting and maintaining coastal biodiversity, regulating local climate, reducing the effect of waves and winds, thus, protecting coastal communities from natural disasters. They prevent both coastal erosion and excessive silt deposits by trapping part of the coastal sediment and saline water brought inland by the sea. Many economically important local fish, crustacean and prawn species use mangroves as a spawning area and habitat in the Porbandar coast, which directly affects local livelihoods.

In the face of uncontrolled greenhouse gas emissions and deforestation trends globally, all bets are currently on such large-scale coastal afforestation projects for immediate and localised adaptations to the otherwise intimidating climate crisis. Aside from the obvious need to protect the existing green cover, if these ongoing efforts show positive results, such ecosystem-based intervention interventions may form a useful and replicable model in other parts of the world.

Addressing the current issue of climate change will require strengthening the communities by enhancing their adaptive capacity. A holistic approach based on the principal of sustainable development which addresses the impact of climate change on local economy without compromising the local ecosystem and societal construct is very crucial. In the present time the most implemented adaptive responses to climate change in coastal areas are aimed at using engineering solutions which are often focused on creating a barrier. Some examples of engineering solutions are building dams, reinforcing seawalls, levees and channels to control flooding, and repairing or relocating infrastructure and even whole settlements (Hale, Lynne & Meliane, 2009). The problem with such approach is that they are often expensive interventions and doesn't answer the economic and societal concern of the communities. Since the impact of climate change will not just be physical such interventions are sufficient to address the full scope of climate change impacts, and can exacerbate the destruction of fragile ecosystems, further reducing their ability to adapt.

Coastal ecosystems are some of the most productive yet most threatened ecosystems in the world (Agardy et al. 2005). Understanding coastal ecosystems, their wide range of social, economic and biological values and how coastal ecosystems contribute to, human and ecosystem adaptation to climate change is an essential first step in planning towards the long-term maintenance of the ecosystems and effective adaptation (UNEP, 2016). The International Union for Conservation of Nature (IUCN) suggests that in order to achieve sustainable development, reaching global biodiversity target and addressing global climate change, nature-based solutions should be treated as integral to adaptation strategies at global, national and local levels. Nature based solution that utilizes the potential of ecosystems and their different services to address the climate change vulnerability and helps build climate resilience is called Ecosystem Based Adaptation (EbA) (IUCN, 2017).

AIMS AND OBJECTIVE:

- Assess the socio-economic indicators of coastal communities to identify vulnerability levels
- Undertake consultations with the local forest and fisheries departments to understand the key issues and the most appropriate solutions
- Design a questionnaire that includes questions related to basic profile of households, observed meteorological changes, extreme weather events, livelihood impacts, indigenous practices
- Conduct a sample survey to gather direct information from the most vulnerable communities and undertake a qualitative and quantitative analysis

- Develop an inclusive plan of action for resilience-building based on indigenous nature-based solutions

METHODOLOGY:

For the proposed study we are adopting a cross-sectional survey methodology. This method is most suitable for the proposed study as it focuses on collecting insights from a target audience at a particular time interval. This survey research method is implemented in various sectors such as household, retail, education, healthcare, SME businesses, etc. Cross-sectional survey research can either be descriptive or analytical. It is quick and helps researchers collect information in a brief period. Researchers rely on the cross-sectional survey research method in situations where descriptive analysis of a subject is required.

During the survey, it was ensured that representative samples of every section of society are taken. Discussions were held with men, women, youth, elderly citizens, and people from all communities/castes. Before starting the survey, each village community along with local Government officials were sensitized about the objective of this study. The team obtained informed consent from participants, and ensued their privacy and confidentiality.

The steps involved in the research are:

✓ Data compilation and cleaning

Plan of Survey

- Questionnaire formulation: Guiding questions were listed and structured to form a questionnaire to capture the understanding and perceptions of the target respondents
- Team Formation: Five teams were formed consisting of a junior and a middle-level staff from AKAH field Office in Porbandar
- Training of the Team: Training session on the questionnaire and data collection objectives and methodology was conducted
- Pilot Study: Three teams were sent to one village and other two teams to another village for pilot testing of the survey methodology. The teams were then brought together, results generated by each team were discussed, anomalies and inconsistencies were discussed, and recommendations for coherence in methodology was established
- Village allocation & survey plan: Every team was assigned villages for every week. A plan was shared with all survey team members.
- Survey: The Survey was conducted via personal interviews with the help of the KoBo Collect App. It was ensured that the respondents consisted of people from all age groups, castes, economic status
- Evidence: Photography and Videography were done for every HH survey. Additionally, general village photography & videography were also undertaken to give the team a sense of the location & susceptibility
- Data Review: Project senior team at AKAH reviewed the results and shared feedback and suggestions with data collection team on a weekly basis
- Data cleaning & compilation: Teams were required to check data and clean any erroneous details before sharing data with AKAH senior team.
- Data analysis: Further, AKAH senior team conducted analysis of the data and conducted weekly sessions with the field team to discuss the results of every villages

Survey Questionnaire

The survey questionnaire was designed with the aim to understand the current status of the local communities and the impact of climate change as experienced by the communities. The questionnaire focused upon the following six points to better understand the local conditions. A detailed survey questionnaire is attached as an annexure.

1. Demographic and Farm Characteristics of the Respondents
2. Community perceptions of meteorological change over the last 25 years and perception on flood, cyclone, drought and other hydro meteorological hazards
3. Community perceptions about climate change risks, impacts and level of severity
4. Perceived impacts of climate change on crops production
5. Farmers perception on adaptation responses towards climate change
6. Constraints to climate change adaptation

Table 1 Detail of the Sample Size

S.No.	**Villages**	**Taluka**	**Approx. Population**	**ApproxHouse holds**	**HHs surveyed**
1	Mocha	Porbandar	1,219	244	22
2	Gorsar	Porbandar	1,366	273	29
3	Untada	Porbandar	1,398	280	22
4	Navi Bandar	Porbandar	1,432	286	30
5	Chingariya	Porbandar	1,835	367	39
6	Ratiya	Porbandar	4,415	883	91
7	Odadar	Porbandar	6,455	1291	127
8	Balej	Porbandar	7,670	1534	150
9	Ranavav (4 vulnerable wards of NP)	Ranavav	20,556	4111	413
10	Madhavpur	Porbandar	24,289	4858	481
Total			**70,634**	**14,127**	**1404**

RESULTS AND DISCUSSION:

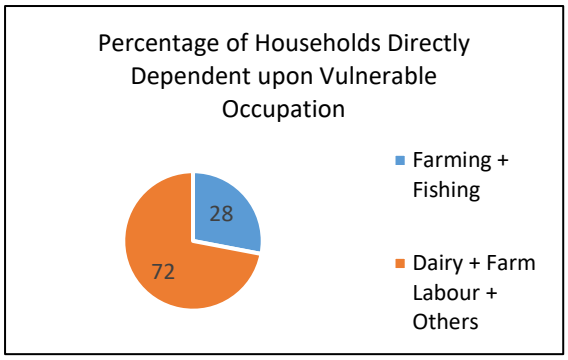


Figure 1 Respondents Practicing Occupation Exposed to Climate Vulnerability

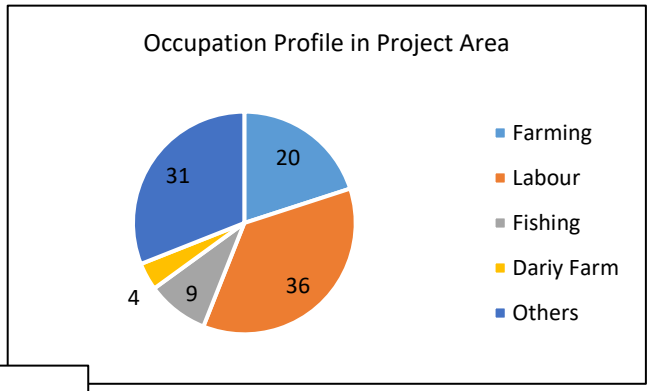
Our interaction with the local communities suggested that a major source of livelihood was related to agriculture allied sector. 28% of the respondents were directly practising farming and fishing as a primary source of livelihood, while others were associated with allied sectors through labour work and dairy industries (Figure 1). Agriculture and fisheries are the two most vulnerable sources of livelihood which will be impacted by climate change.

In fact, most of the jobs reported under 'Others' are also climate-dependent including shops and driving which have been affected by unexpected extreme weather events.

The compilation of major sources of livelihood revealed that agriculture was the most important source of livelihood for most of the people in the villages that were studied during the survey. (Figure 2) reveals that around 57% of the population is directly or indirectly (as a farm labourer) dependent upon agriculture for their livelihood. 31% of the total population is dependent upon other jobs and skill-based activities for income generation.

Even though the selected villages were coastal villages, only 9% of the population is engaged in fishing related activities for their livelihood while the remaining 4% of the population is engaged in dairy farming and related activities.

However, in Village Navibandar, about 90% households depend on fishing as their primary source of Income.



2 Composition of Major Sources of Livelihood in Area

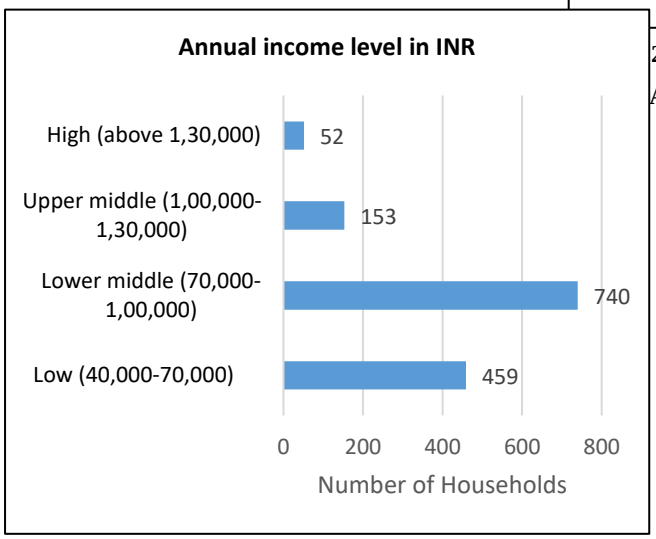


Figure 3 Distribution of Respondents as per Income Earned Annually in INR

According to the average annual incomes, the respondent households were categorized as High income, Upper-middle income, Lower-middle income, and Low income. More than half the households fall within the lower-middle income group of about INR 70 thousand to INR 1 Lakh in a year. About 85% of households fall within the low and lower-middle income groups ranging from an income of INR 40 thousand and INR 1 Lakh in a year.

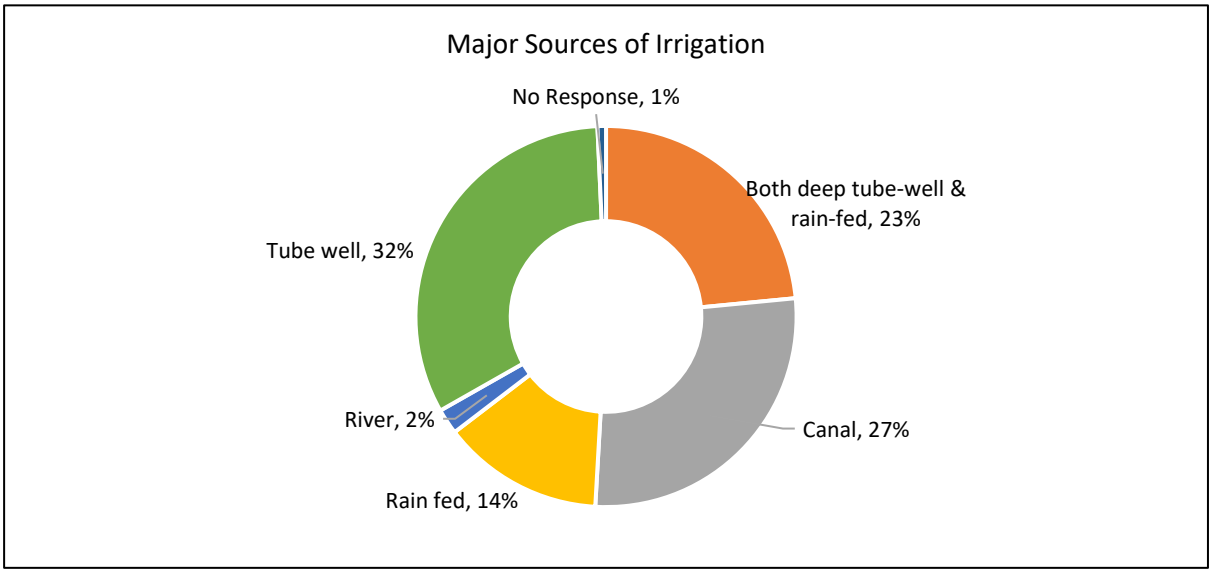
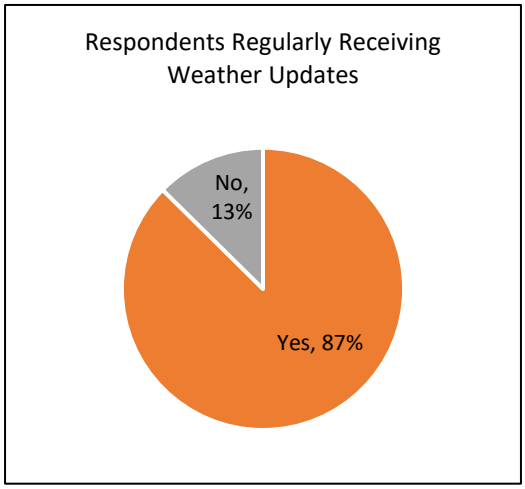


Figure 4 Major Sources of Irrigation

The agriculture in the study area is heavily dependent upon artificial source of irrigation. As shown in (Figure 4), 37% of the respondents said that they are dependent on rainfall for their irrigation requirement. 280 respondents were directly associated with farming as their main source of livelihood. Out of those, 38 (14%) of the respondents said that they are completely dependent upon rain for irrigating their farm, while 64 (23%) of the respondents said that they were dependent upon rain but they also had access to deep tube well.



Upon asking whether or not they receive information about weather updates regularly, around 87% of the respondents said that they regularly receive weather updates. It is crucial for the fisherman who goes for weeks in the deep see to have a weather forecast before going into the deep sea. Likewise, farmers need accurate weather information to decide the time of sowing of new crops as it is generally associated with the first rain of the season. Hence weather updates were crucial for the local communities.

For most of the respondents, the major source of weather updates is new channels and other forms of media. Other major sources of information are village elders, friends and family members who implement their wisdom and experience to forecast the weather pattern.

Out of 120 respondents who have fishing as their primary source of livelihoods, about 70% agreed to receiving weather information. On the other hand, out of 277 respondents who have farming as their primary source of livelihoods, about 90% reported receiving weather information regularly.

Understanding the Impact of Climate Change from Farmer and Fishermen's Perception

Our interaction with the local communities revelled that people perceive climate change in their unique manner which is largely dependent on their inherent and livelihood related vulnerabilities. The team specifically assessed the perceptions of the farming and fishing households as their livelihoods are directly dependent on any weather and climate change.

About 80% of fishing households reported High number of incidences of heavy storms that affect their work and lifestyle. Interestingly, none of the respondents reported to receiving 'No', 'Low' or 'Very

Low' Heavy Storms. When asked "How frequently below-mentioned climatic hazards are occurring in your area?", most of the households expressed concerns over the rising storms.

About 56% of farming households reported High and Very high number of incidences of floods that affect their crop. When asked "How frequently below-mentioned climatic hazards are occurring in your area?", most of the households expressed concerns over the rising floods

The findings suggest that there are increasing cases of flood, heavy storms and other extreme weather events. The temperature is getting warmer and there are increased cases of heat waves experienced by the local population along with increased number of days with extreme winds and heavy storms.

Perception of Local Farming Communities on the Impact of Climate Change

The analysis of response given by the respondents on various questions regarding the impacts of climate change are discussed here.

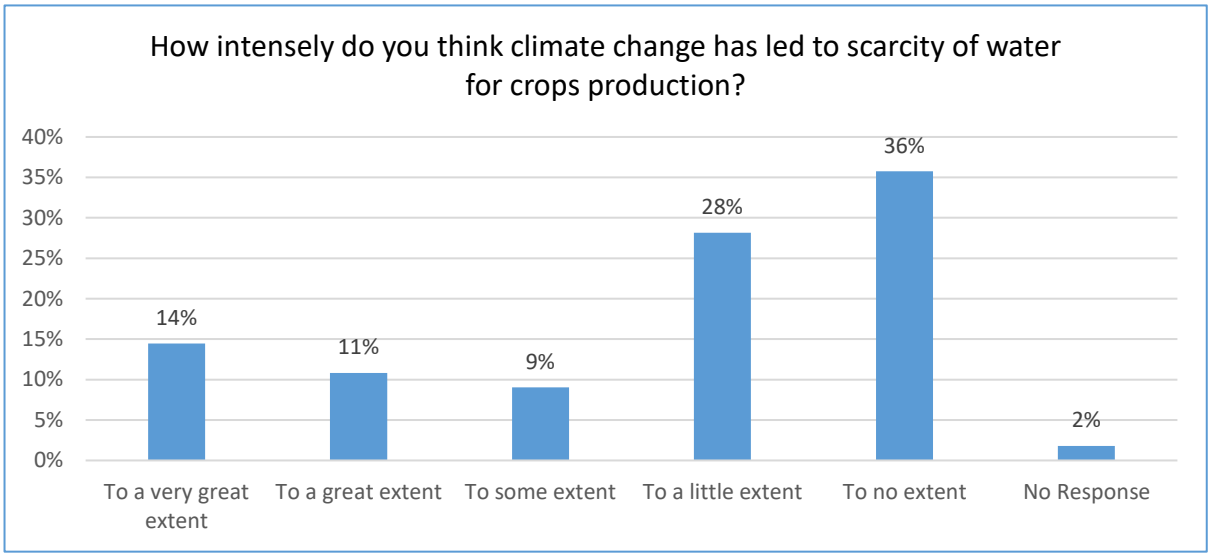


Figure 5 Perception of Farmers on Impact of Climate Change on Crop Production

Impact of climate change on water availability is a major concern across the globe. The response of the survey suggests that the impact of climate change on the water availability is low. 36% of the respondents said that there is no impact while 28% said that there is a little impact on water availability for irrigation.

When asked about whether the respondents have experienced an increase in the cases of crop diseases due to climate change majority of the respondents suggested that there is an increase in the crop diseases due to climate change. 28% of the respondents suggested that there is a great increase while 50% of the respondents suggested that there is an increase of some level due to climate change in crop diseases.

Key Reasons for Reduced Crop Production & Farm Income

Questions	Response
Does drought damage your crops production and agricultural income? If yes, then how	A collective consensus was that unexpected extreme weather events like drought were one of the factors leading to reduced yield resulting in significant reduction in farm income. As many farmers are dependent upon rainfall and tube well, increased number of days without precipitation causes problems for irrigation, thus reducing the overall productivity.
Does flood and sea erosion damage your livelihoods and agricultural sector? If yes, then how does it affect?	The rainfall pattern has changed significantly; the number of rainy days has decreased but the amount of rain has increased. This results in higher quantum of water reaching the fields in a quick succession causing water logging and flood like situation.

	This has led to increased diseases in crops. Many farmers have registered that due to excess water, plants are catching diseases easily causing crop damage. Heavy water logging is also a reason for poor soil quality, as mentioned by some of the respondents.
Do extreme temperatures and heat waves influence your agriculture field? If yes, then how it affects production?	Heat waves were reported to be particularly damaging to the crops. The number of days with extreme temperature have increased significantly leading to crop failure as most of the crops do not flourish in such high temperature and extreme conditions.
Has the soughing or harvest timing changed over the last 10 years due to weather and climate changes?	>200 respondents from 277 farming households (73%) reported change in the timing of farming. The time for soughing and harvesting has seen a delay due to erratic rainfall in the recent years.
Have you changed the crop type over the last few years due to reduced production and/ or degrading quality of produce?	Some farmers have changed the crops to cope up with the climatic changes. 180 respondents out of 277 farming households (65%) reported that they had to change the crop in order to increase the farm production and income. They specifically reported the declining quality of crops as well as crop failure as one of the reasons of changing crop type.

Farmers perception on adaptation responses towards climate change

Local communities have been affected with various climatic and natural changes eventually resulting in decline in the socioeconomic status of the communities. This section presents the finds of various adaptive measures taken by local communities, barriers and their perception about climate change adaptation.

Adaptation Measures Applied by the Local Communities	• Taking up crop Insurance for when the crops fails. • Make use of Government Subsidies for reducing the cost of farming. • Changes were made in the crops selection by selecting resilient crops which can withstand the climatic changes • To protect the crops from saline winds, the locals plant coconut tree barriers and cover the crops with clothes like saree • Some try to change the crops to more resilient species which can withstand the climatic changes. • Implement agroforestry and intercropping to address the declining production. • Use traditional techniques for soil and pest management and organic farming to reduce the cost of production.
Details of Financial assistance taken by the locals	Major financial assistance came in the form of • Crop Insurances • Government Subsidies
Suggestion on additional initiatives to build resilience to climate change within the livelihoods of the village	Major problems are flooding, water logging, heat waves, more number of dry days and salinity ingress. There is a need for implementing watershed management strategies irrigation water, building bio-barriers from mangroves and Sharu trees to check salinity ingress and implementing flood control measures. Training & Capacity Building of the locals on latest technology, natural farming methods and resilience. Awareness on schemes and other financial instruments. Adopting natural farming to reduce input coast and increase farm income. Provide local alternate sustainable livelihood options to diversify income sources for the local communities.

UNDERSTANDING THE LOCAL VULNERABILITY

A large percentage of community members are dependent on climate-dependent occupation in Agriculture and allied Sector

The study revealed that 73% of the respondents are engaged in agriculture and allied sector like farm labourer, dairy and cattle raising as their primary source of income. This means that most of the population is directly or indirectly exposed to the negative effects of climate change. The study further reveals that 32% of the respondents were directly engaged in farming, 30% of the respondents were working in the farm as cultivator, harvester or any other farm related labour work and 11% of the respondent were engaged in dairy related activities for their main source of income.

Major Impact:

- A decline in the agriculture productivity due to degrading ecology and climatic pressure. The major factors affecting crop productivities remains uncertain rainfall, extreme temperature, increased number of hot days, delayed seasonal onset, flood/drought like conditions etc.
- Economic loss due to crop failure as major source of livelihood is farming. Many people depend upon labour work related to agriculture lose jobs due to decline in farm productivity. Degrading condition further increases the cost of farming, hence reducing the profit generated from the produce.
- Water availability for irrigation has become a major issue, intense rainfall with fewer rainy days often cause flood like situation and doesn't allow water to permeate through soil and recharge the aquafers. Thus water for irrigation remains a major concern.
- Majority of the farmers are practicing crop residue burning, which has caused soil degradation and is affecting farm productivity and soil's microbiome.
- Loss of livestock due to floods, extreme heat and temperature. Recent time has seen a significant rise in extreme conditions which are not suitable for cattle. Coupled with unavailability of regular medical facility and infrastructure for cattle, climate change significantly increases the pressure on local livestock holders.
- Local fishing communities are observing a steep decline in the quality and quantity of fishes in the ocean. The main occupation of the people of Navibandar village is fishing and small industries run on it. For 7 months, the access to the sea for fishing becomes difficult for the fishermen to take their boats to the sea due to sand dunes. At Navibandar village, Bhadar River forms delta with Arabian sea. During monsoon, water of Bhadar River brings heavy mud that gets collected near seashore of the village. Due to this reason, it is very difficult for fishermen to take their boats for fishing.

Loss of local flora and fauna in the recent time from the area

Some species of flora as well as fauna are not found in the area anymore. These include:

Faunal Specise	Floral Species
• Jackal (*Siyar*) • Fox (*Lomdi*) • Hyena (*Jarak*) • Badger (*Vinj*) • Porcupine (*Sedhadi*) • Vulture • Parrot	• *Prosopis cineraria* (jand-known as Khijdo in local language) • Ceylon ironwood (Known as Rayan in local language) • *Ficus religiosa* (*Peepal* in local language) • Indian Almond

• Crow • Khera	• Bitchwood tree (called Savan or Sivan in local language) • *Tamarindus indica* (Tamarind) • *Ficus amplissima* (*Pipri* in local language) • *Ficus benghalensis* (Banyan tree) • *Cordia monoica* (Saucer berry, Kat gundi in Gujarati) • Gum Arabic tree (Desi Babul)

Interaction with the local communities has given some interesting insight on the vulnerability of the people living in the coastal villages of Porbandar district. The most important characteristic of the rural settlement is its affinity towards natural parameters like ecosystem and climate, since most of the people living in the rural areas are predominantly dependent upon agriculture and allied sector as their primary source of livelihood.

Table 2 Major Climatic Pressure Points and Its Impact

Drivers	Changing climate patterns
Pressure	• Increasing Salinity in soil & water • Extreme Heat • Strong winds • Erratic rainfall
Status	• Reduced Soil fertility • Reduced crop produce • Increased crop-pest incidence • Reduced fish quantity & low quality • Increased instances of flood, drought, storm surge
Impact	• Reduced farm income • Reduced fisheries income • Damage to life and infrastructure during disasters

Agriculture is a sector which needs healthy environmental conditions to flourish, and it is completely dependent upon the climatic parameters for efficient production. Climatic parameters are few such variables that are not under the control of human being, hence the human system needs to make adjustments according to the climatic behavior and changes.

Additionally, biodiversity is impacted by climate in long-term and weather conditions in day-to-day functioning. Life perpetuates in suitable climatic conditions. Climatic variability, a natural phenomenon, has played a significant role in shaping current ecosystems through species redistributions, extinctions, and originations. Climate change has led to habitat alteration and thus has threatened key species due to amplified extreme weather events including floods, heat waves, and wildfires.

INDIGENOUS PRACTICES

During our research, the team identified several indigenoug practices being followed by the local communities to build resilience to climate change through safeguarding themselves from the key adverse impacts of climate-induced risks.

- **Bhungroo:** Bhungroo is a traditional technique used for restoring ground water during monsoon. Bhungroo means “Straw” which is traditionally used to draw excess of water from water logging into the depth of the grounds.
- **Mulching:** A simple practice of mulching has the potential to significantly reduce the water demand in the field. Mulching will also solve many of the soil nutrition problems. Currently crop residue burning is a being practiced by most farmers, which is a major reason for soil degradation, air pollution and carbon emission.
- **Holiya Technique for Controlling Water Logging & Salinity:** This method is widely used in Patan and Banaskantha regions, where issues of salinity and flooding due to clayey soil are prevalent. By diverting flood water for aquifer recharge, holiya helps prevent damage to the crops and enhances water availability during the Rabi season. Farmers have reported about 20-25 percent increase in production due to enhanced drought resilience with this method. In the current climate context, holiya can provide a simple solution to farmers in the region, to simultaneously address the challenges of salinity, flooding and drought.

  Under this technique a recharge well of about 9-12 metre deep in a lower part of the farm is constructed. A pipe with perforations at one end is inserted into this well through which water can flow down recharging the groundwater. The upper end of the pipe is housed in a square-shaped concrete collection pit with sides of one metre or less (Climate Change Department, 2022).
- **Organic Farming**: Several conscious young farmers practice organic farming based on cow-based natural agriculture. In this process, they do not use any kind of pesticides or chemical fertilizers in fields. They utilise cow dung, cow urine, and using various natural remedies to produce completely organic vegetables. Such farmers are also providing training to fellow farmers who are interested in organic farming.

  Over the years, the local community has realised the importance of organic farming. Consequently such farmers do not have to go looking for buyers for the organic produce. People come directly to the farm, as they know that the prices are affordable and they will get nutritious organic food. The demand for organic vegetables and pure cow *ghee* (Clarified butter) from the farm keeps increasing day by day.

RECOMMENDATIONS & FURTHER ACTION:

Through secondary and primary research, it was understood that biodiversity can be utilized for building resilience of communities to climate change in two ways

1. Physical defence to climate change induced disasters like storms
2. Biodiversity-based livelihood including fruit-bearing trees

As part of the project, more than 20,000 fruit-bearing trees have been handed over and planted across 10 coastal-villages to provide alternate income opportunities to >2000 local families. Additionally, about 100,000 mangroves and similar plant species have been planted along the coastline in Porbandar, Gujarat involving the local population. The team is also geo-tagging the plants, putting-up sensors and cameras to help monitor the growth.

While on one side, this nature-based solution is anticipated to protect the coats and coastal communities from climate-induced disasters and harsh saline winds, on the other side, this nature-based solution has provided communities with alternative livelihood opportunity both during plantation (community was paid for plantation) and once the vegetation grows.

Physical Defence to Climate Change:

Coastal ecosystems are especially good at storing carbon because of the thick, rich layers of soil they build up. In most forests, when trees die, they release their carbon back into the atmosphere. But in many coastal ecosystems, when plants die, they don't fully break down, and their carbon can stay trapped in water-logged soils for thousands of years. In fact, mangroves store three to five times as much carbon per acre as other tropical forests. Coastal wetlands can also store carbon that comes from other ecosystems, by filtering out carbon-rich sediments suspended in river water as it flows out to sea. Because coastal ecosystems are such potent "carbon sinks," the loss of these habitats is an important driver of climate change (Donato et al., 2011).

Coastal habitats are actually one of our best ways to protect coastal communities from climate change. During hurricanes and other storms, high winds can push walls of water toward shore. Coastal habitats absorb energy from incoming waves and slow down these storm surges. As sea levels rise and hurricanes become stronger, we will need this protection more than ever (Duarte et al., 2013).

A major recommendation is strengthening the mangrove forest across the cost line of for protection against the coastal extremes. As per (Small & Nicholls, 2003), mangroves play a very important role in providing physical defence to the coastal regions as explained below;

- Mangroves reduces wave damage: During the storm, wind and small waves loses its momentum as they pass through the mangrove, significantly reducing the impact.
- Mangroves reduces the damage from Storms: Wide areas of mangrove with dense plantation can protect against storm surges and resulting flooding.
- Mangroves can help decrease the impact of Tsunami: A dense plantation of mangrove over a wide are is capable of reducing the height of tsunami, thus protecting life.
- Mangroves helps reduce soil erosion: Mangroves has above ground roots which encourages sedimentation and reduces soil erosion besides binding the soil and providing strength to the soil.

Biodiversity Based Livelihood Diversification

Consultations were conducted with forest-department, fisheries-department, climate-change department, State Disaster Management Authority and local CSOs. Discussions with local Government led to identifying the need to safeguard lives through creating green wall/natural infrastructure by plantation of Mangroves and other plants: Avicennia marina (Mangrove), Casuarina equisetifolia (Saru), Salvadora persica (Pilu), and Ravan tad (a local Palm species). It has been suggested to use these species as multi-layer natural-defense against saline-winds.

In addition, for protecting livelihoods, income diversification and alternative livelihoods have been suggested. Communities have been suggested to practice the Fish culture method. The fishing community is being assisted to plant species like Saru, Pilu and other coastal native species for natural defense against saline-winds. The farming community is being assisted in planting native fruit-bearing trees like Jamphal (Guava), Jamun (Java plum), Coconut, and Mango to get additional income.

There were one-to-one discussions as well as focus group discussions with all sections of the community to discuss the issues faced, meteorological changes over the years, changes in soil quality, changes in water availability, changes in fish catch, threatening storms and floods, availability of timely weather-alerts, and traditional indigenous practices.

There are numerous indigenous practices being adopted by coastal households for improving water availability through watershed management including Holiya technique and traditionally controlling salinity in groundwater and soil. The Green Hedge is also built up, made up of shady trees, creepers, shrubs and bushes such as Kharkhodi, Samardudheli, Kankodi, Fanj, Kanska, etc., which form a natural green wall that protects the farm from livestock and winds. This project also documented such practices and is working towards strengthening these.

Summary

This research aligns well with the theme of 'Alternative, nature-based solutions for sustainability challenges (including perspectives from indigenous people)'. The study focused on developing an Ecosystem-based Approach for climate-resilience, building upon the rudimentary and small-scale indigenous practices for physical protection of life and infrastructure; enhanced water availability; improved soil quality –all through nature-based solutions.

The project is successfully working towards promoting ecosystem-based approach focusing on climate-resilient livelihood opportunities to complement agriculture and fishing which are stressed due to climate-shocks. However, these initiatives need to scaled-up and replicated for better learning and adoption of best practices.

Such initiatives can be successful through the involvement of all key stakeholders including national, state and local Government, think-tanks, local CSOs, research institutions and local communities. There needs to be concrete time-based action at all the levels including:

- Policy-level
- Finance
- Research & Development
- Ground implementation
- Documentation & knowledge transfer

There is growing evidence about the success of such nature-based solutions and indigenous practices that have immense scaling-potential. There is an urgent need to earmark and direct adequate resources for implementing and scaling-up such evidence-based successful nature-based solutions for building climate resilience.

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